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THE AGE OF ICE.[1]

TILL within a comparatively recent time, geologists regarded the climate of the prehistoric periods as tropical or warm temperate. Those who first sought to explain the presence of certain scratches upon ledges, by the action of moving ice in continental masses scouring the surface, were met by ridicule and skepticism. The writer has now before him a caricature devised to illustrate the notions of the literary world upon this subject thirty years since in England. The excellent Dr. Buckland appears clad in furs, such as are required in Greenland, with a map of ancient glaciers under his arm, showing markings made on the rocks 33,333 years ago. On one side is represented a bridge with a scratched paving-stone at the entrance, and an inscription like this: "Scratches made day before yesterday by a cart-wheel passing over Waterloo Bridge." It is said that the learned doctor was greatly amused by the sketch, and sent copies of it to all his scientific friends. The one before us bears his autograph.

But within the last three decades numerous observers have carried out the suggestions of the earlier geologists to a very extensive application. Forbes and Agassiz explored the glaciers of Switzerland in order to learn the laws of ice-motion; Lyell, Murchison, Ramsay, and others, have ransacked the fields of Great Britain in search of facts from which to generalize; and, in our country, Hitchcock, Mather, Whittlesey, Newberry, Dana, and a score of younger men, have made the investigation of the drift period a matter of enthusiasm. The existence of an immense era when all of Northern America and Europe was enveloped by enormous thicknesses of solid ice, crunching fragments of rocks beneath its massive tread, and transporting square miles of moraine rubbish upon its back, is now universally accepted. Some have gone so far as to believe that the entire globe was encircled

[1] The Great Ice Age, and its Relation to the Antiquity of Man. By James Geikie, F. R. S. E., F. G. S. 575 pages. D. Appleton & Co.

in these arctic fetters—as illustrated by the Brazilian researches of the lamented Agassiz.

One of the latest and most extensive works relating to the Ice period is given to the world by James Geikie, of the Royal Geological Survey of Scotland. The subject is treated of with special reference to the phenomena exhibited in the north of Europe. He subdivides the Ice age as follows:

1. *Preglacial Period.*—This is seen best in the "Norwich crag," where remains of the elephant and mastodon are found in peat-beds, and these are indications of approaching cold.

2. *First Cycle of Cold.*—This exhibits intense glacial conditions, with great confluent glaciers; intermediate mild and warm periods; arctic and southern mammalia visit Britain alternately, according as climatal conditions become suited to their needs. This is followed by an arctic climate with the mountains covered by snow and ice, the glaciers ceasing to be confluent. The era terminates with local glaciers. The deposits laid down are chiefly the "till" and "bowlder-clay," with a few stratified sands.

3. *Last Interglacial Period.*—In this Britain is at first insular, with cold climate; next continental, with climate changing from cold to temperate and genial, and again to temperate. In early stages of the continental condition, the arctic mammalia invade Britain. Subsequently these disappear, and are succeeded by the hippopotamus, etc.; afterward submergence ensues, and the islands are again insulated, perhaps before the climate became again suited to arctic mammalia. At the close of this period the land sinks, reaching the depth of 2,000 feet below its present level in Wales. The deposits of this era are cave-accumulations, river-gravels, and high level beaches. The human implements found with the extinct mammalia are of stone, and of the rudest construction.

4. *Last Glacial Period.*—This was a time of floating ice, comparable with the conditions imagined by the earlier writers for the whole drift period. The climate was arctic, icebergs floated over most of the land, enormous blocks of stone got stranded upon the hill-tops, moraines clogged up valleys, and toward the termination of the period local glaciers manifested the final effort of the ice to gain the mastery. Remains of boreal shells and the mammoth occur for the last time in the frozen sands and ancient beaches.

5. *Preglacial Period.*—The land has regained its present level, terraces are formed by immense rivers, arctic forms of life have disappeared, and the era of bronze and iron implements shows what progress man has made in the arts.

Till.—Throughout the length and breadth of Scotland occur scattered heaps and ragged sheets of sand, gravel, and coarse *débris*, together with wide-spread deposits of clay largely obscuring the solid ledges. In the Highland and upland districts these deposits seem to be

FIG. 1.

GREENLAND GLACIER.—The Ice breaks off in immense Masses.

largely restricted to the valleys, while in the Lowlands they spread in broad sheets, continuous over wide tracts. The very bottom earth is a strong clay or till, much like our hard-pan, which is therefore older than any of the overlying deposits. Their relations are shown in the accompanying figure.

FIG. 2.

DIAGRAMMATIC SECTION, SHOWING RELATIVE POSITION OF TILL *t t* × AND OVERLYING SAND AND GRAVEL SERIES *S S* ×. *W.* = RIVER VALLEY.

This till is so tough that engineers would much rather excavate the most obdurate rocks than attempt to remove it from their path. Hard rocks are more or less easily assailable with gunpowder, and the numerous joints and fissures by which they are traversed enable the workmen to wedge them out often in considerable lumps. But till has neither crack nor joint; it will not blast, and to pick it to pieces is a

FIG. 3.

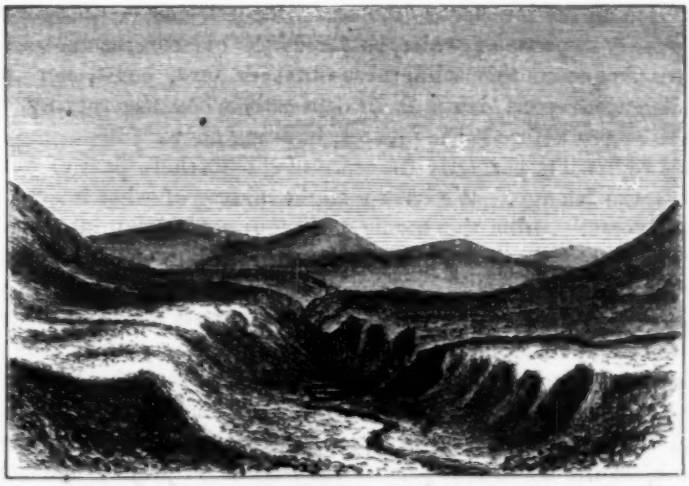
SCRATCHED STONE (Black Shale), FROM THE TILL.

very slow and laborious process. Should streaks of sand penetrate it, water will readily soak through, and large masses will then run or collapse, as soon as an opening is made into it.

The percentage of stones present is variable. They are most common in the hilly districts, while in the lowland region the clay may predominate. Most of them show markings all over. They vary in size from grains to blocks several feet or even yards in diameter. Their shape is peculiar. They are neither round nor oval like the pebbles in river-gravel, or the shingle of the sea-shore; nor are they sharply angular like newly-fallen *débris* at the base of a cliff; but seem to be like the latter in general shape with the sharp corners and edges smoothed away. They are to the geologist what hieroglyphics are to the Egyptologist—the silent but impressive records of an age long passed away.

In narrow valleys the till often accumulates in such amount as to cover the solid floor many yards in depth. In such cases, the surface may be level, and, in the subsequent periods, the streams have made excavations in the mass, leaving the till in the terrace-form. Its unstratified character will be determined by examining the earth along

FIG. 4.



GRESKIN BURN, DUMFRIESSHIRE.—STREAM CUTTING THROUGH TERRACE OF TILL.

the sides of the escarpment, as, superficially, it is difficult to distinguish the material from the terraces of later age.

When the till is removed from the underlying rocks, their upper surface almost invariably shows a smoothed and often highly-polished appearance, and the whole pavement is marked with those peculiar scratches or striæ that form so characteristic a feature of the embedded stones. The extent to which the polishing is carried depends very much upon the nature of the rock. As the best-preserved stones of the bowlder-clay consist of close-grained limestone and clay iron-stone, so the same materials in the ledge-condition preserve most perfectly

the fine lines of striation. The soft sandstones and highly-jointed rocks are much less finely marked, and often show a broken and shattered surface.

GREENLAND.—To understand the appearance of Northern Europe in the Ice period, we may consider the features presented by a similar ice-covered country in modern times, and no country will better illustrate this phase of geological condition than Greenland. This island is almost continental in its dimensions, containing not less than 750,000 square miles, and is all a bleak wilderness of ice and snow, save a little strip extending to 74° north latitude along the western shore.

The coasts are deeply indented with numerous bays and fiords or firths, which, when traced inland, are almost invariably found to terminate against glaciers. Thick ice frequently appears, too, crowning the exposed sea-cliffs, from the edges of which it droops in thick, tongue-like, and stalactitic projections, until its own weight forces it to break away and topple down the precipices into the sea. The whole interior seems to be buried beneath a great depth of snow and ice, which loads up the valleys and wraps over the hills. The scene opening to view in the interior is desolate in the extreme—nothing but one dead, dreary expanse of white, so far as the eye can reach—no living creature frequents this wilderness—neither bird, beast, nor insect. The silence, deep as death, is broken only when the roaring storm arises to sweep before it the pitiless, blinding snow.

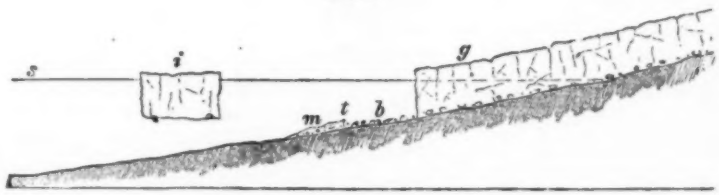
This represents perfectly the state of the northern part of our continent in the Ice age. We have a slight inkling of what it must have been universally, from the heroic messages sent down in the winter from the meteorological observatory stationed upon the summit of Mount Washington.

Some of the Greenland glaciers attain a vast size. Dr. Kane reports the great Humboldt glacier (*see* Fig. 1) as sixty miles wide at its termination. Its seaward face rises abruptly from the level of the crater to a height of 300 feet, but it is not known how deep it may extend under the sea. Another important ice-stream is the Glacier of Eisblink, on the northwest part of the island. It projects seaward so as to form a promontory thirteen miles in length. It comes from an unknown distance in the interior, and plunges deeply into the sea.

Since ice is lighter than water, whenever a glacier enters the sea the dense salt-water tends to buoy it up. The great tenacity of the frozen mass enables it to resist the pressure for a time. By-and-by, however, as the ice reaches deeper water, its cohesion is overcome, and large segments are forced from its terminal part, and floated up from the bed of the sea, to sail away as icebergs. The glacier evidently crops under the water to considerable depths, or, so long as the force of cohesion is able to resist the tendency of the salt-water to press it upward. The annexed diagram will show how the ice pushes down into the sea, carrying morainic materials at its base, which accumu-

late at *m* ; *t b* may show the origin of the block *i*, which is now going to sea as a buoy. In many cases the icebergs must carry with them stones frozen on the under side, as well as blocks perched on their backs. Dr. Kane speaks of ice-rafts, floating many miles out to sea—tables 200 feet long covered with large angular blocks and bowlders.

FIG. 5.



GREENLAND GLACIER SHEDDING AN ICEBERG.

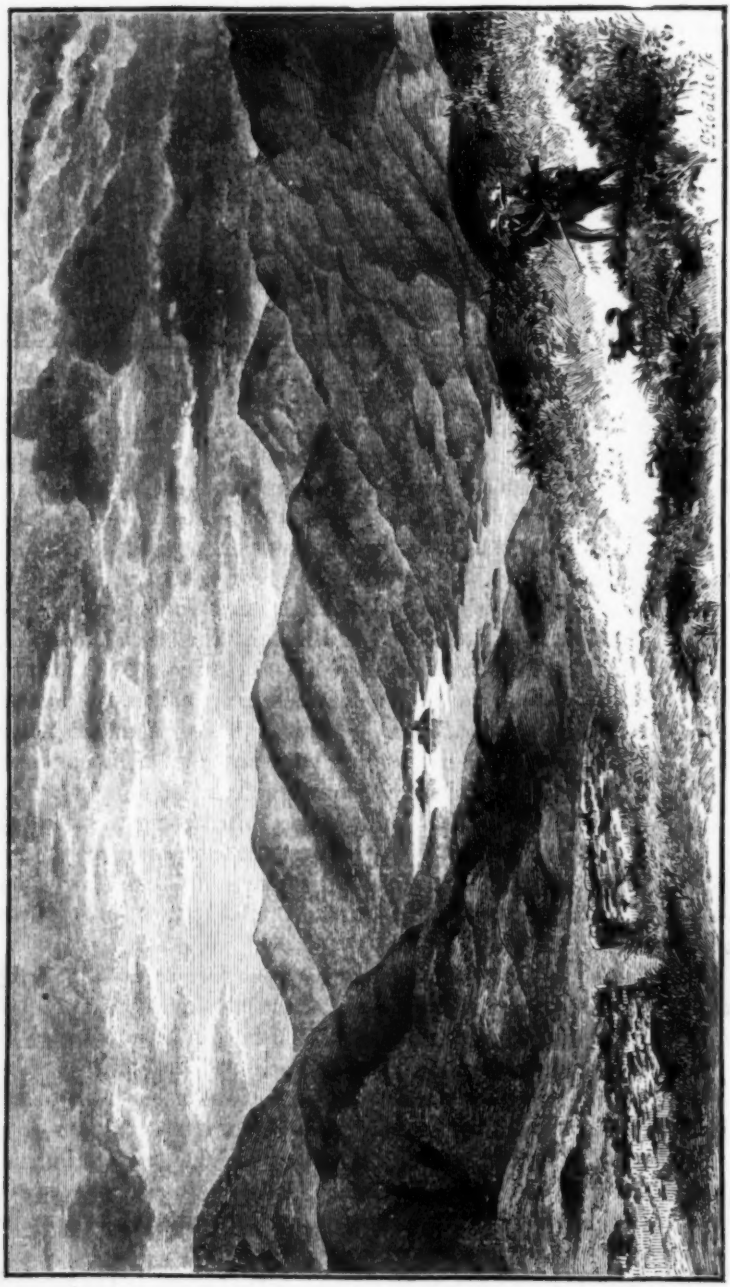
Though Greenland is said to be inhabited only upon the south and west coast, there is a record of an early settlement upon the side toward Iceland, with which there has been no communication for 400 years. The colony was planted about 1000 A. D., which flourished, and maintained intercourse with its mother-country till the beginning of the fifteenth century. Since that time, owing to the setting in of the arctic current, and the consequent gradual increase of ice upon the coast, the colony became inaccessible, and the records of it disappear from history. At various intervals between, 1570, 1751, etc., down to our own time, the intrepid Danes have striven in vain to re-open communication with their lost colony. This emerald coast, with valleys well stocked with reindeer and verdant glades, is now shut in by the pitiless ice-pack, and the fate of its inhabitants ought to excite the interest of the world. It would be very interesting to be informed of the condition of this colony: whether the increasing cold has enlarged the glaciers so as to push the dwellings out to sea, or whether the habitations are still standing, and a population has sprung up who know of the outside world only by tradition.[1]

Lake-Basins.—A strong argument for the former existence of glaciers over the northern regions comes from the excavation of basins from the solid rock for the reception of lakes. The country most traversed by the ice agency abounds in these rock-hollows. It is very evident that the glacier is the only agency which can well be called upon to explain these phenomena. Running water excavates only on a descending plane. Sea-water acts upon its level, while the glacier requires only a pressure from behind to enable it to ascend mountains. The upward movement of the ice is shown by the striæ to have been exceedingly common.

The glacier grinds hardest where the steeper slope is exchanged for a less inclination of its rocky bed; the tendency of this action is to

[1] *Geological Magazine*, vol. x., p. 541.

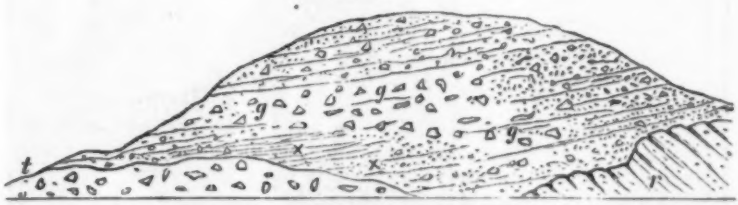
Fig. 6.



Loch Doon (upper reach).—A Rock Basin, supposed to be excavated by Glacial Action.

increase the length of the greater in elevation, or, in other words, to scoop out material from the ledges, in a part of the course, and, after the strength of the graver has exhausted itself, the ice will move up a slope with little energy. This process will excavate hollows that may be filled with water in later times. Such are the basins of the great American lakes. The dimensions of the lakes are areally proportionate to the extent of the drainage-system in which they occur.

FIG. 7.



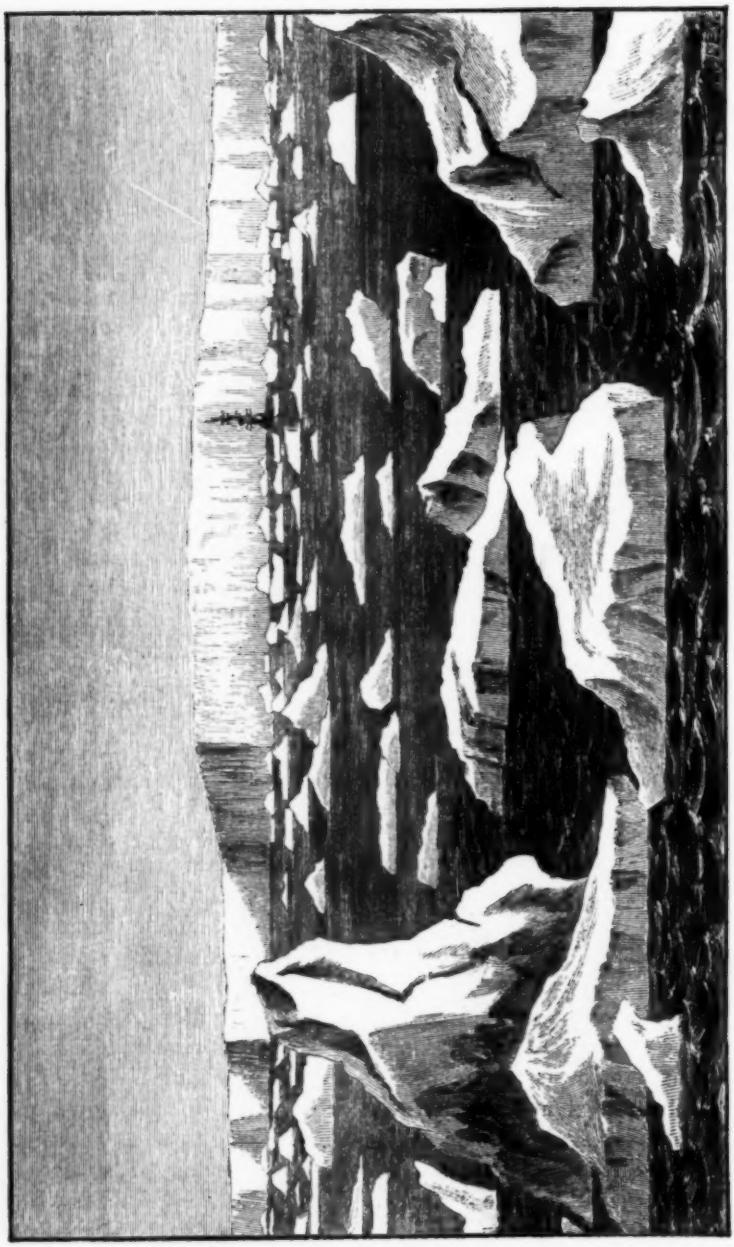
TILL OVERLAID WITH BOWLDER-CLAY, RIVER STINCHAR. *r*, Rock; *t*, Till; *g*, Boulder-clay. ×, Fine Gravel, etc.

Bowlder-Clay.—There is a distinction to be drawn, in Scotland, between the "till" and "bowlder-clay." The two deposits pass into each other on the Highlands, and Mr. Geikie proposes to limit the latter to the maritime districts. The bowlders of the clay are more rough and angular than those found in the till. The annexed section shows where the two deposits come into juxtaposition. This clay has not been met with more than 260 feet in vertical height above the sea. It contains an abundance of shells of *Arctic mollusca*. Possibly it is the "Champlain clay" of America.

Antarctic Ice-Sheet.—From a study of the ice of the Antarctic Continent, it is possible to understand the origin of icebergs, and the transportation of large blocks of stone, in "erratics." The water is deep, and thus buoys, of enormous size, may float northerly for hundreds of miles.

Sir J. C. Ross attained the highest southern latitude on record, but found all his attempts to penetrate farther frustrated by a precipitous wall of ice, frequently 180 feet in height. For 450 miles he found this cliff unbroken by a single inlet. While coasting along this barrier his ships were often in danger from stupendous icebergs and thick pack-ice, extending in masses too compact to be penetrated. At one point the ice descended sufficiently low to allow Ross to look down upon it from the mast-head. The upper surface appeared to be a smooth plain, shining like frosted silver, and stretching away as far as eye could reach into the illimitable distance. In principle, the sheet is the same with that figured in the north, but more extensive. Like this must have been some portions of the glacial sheet in Scotland, when the land was mantled in ice-covering, filling up the intervening straits and channels of the sea, and terminating far out in the Atlantic Ocean, in aflat-topped vertical cliff of blue ice.

FIG. 8.



ANTARCTIC ICE-SHEET.—A precipitous Wall of Ice, 150 feet high, along the Base of which Sir J. C. Ross sailed 450 Miles.

Erratics.—These are of all shapes and sizes, occasionally reaching colossal proportions, and containing many hundred feet. Some are rounded, others are angular, and not a few exhibit marks of scarification. They may rest on base-rock, and, if carefully poised, may be made to oscillate by the form of the land, or these large blocks may appear on the till, angular *débris*, and hills of gravel. As a general rule, they prove to have been carried from higher to lower levels in Scotland, though many exceptions are recorded. There is one at the height of 1,020 feet on the Pentland Hills, which may have traveled westerly as much as eighty miles. It probably passed from one mountain across a wide valley before attaining its final resting-place. This is not so striking as the blocks lying nearly over the recently-completed Hoosic Tunnel, in Western Massachusetts, one of which weighs 510 tons, and has been transported from Oak Hill across a valley 1,300 feet deep. It has hundreds of lusty comrades, scattered in a southeasterly course for thirty miles.

Sometimes a large block is revealed by the washing away of the till around it. Those on the surface of gravel may have been carried by floating ice. To such blocks it is not easy to assign limits of the distance traveled, since icebergs may float for thousands of miles without melting.

Origin of the Cold Climate.—The question of the cause of the glacial cold has been discussed warmly for a long time. The opinion seems to be gaining ground that purely geological causes are not sufficient to account for the magnitude of the glacial distribution. The precession of the equinoxes, changing the times of the seasons, and the eccentricity of the earth's path around the sun, lengthening the winters and increasing precipitation of moisture, when combined with certain changes in the courses of ocean-currents, and some elevation of land in the north, may have together been instrumental in bringing around a period of intense cold. If it be possible to use the orbital changes as a guide to a chronological date for this term of cold, we can say it began about 240,000 years since, and continued for 160,000 years, terminating 80,000 years before A. D. 1260. The cold would have culminated about 30,000 years after its beginning.

Granting such figures, we can understand that the glacial must have been the dark age in the earth's history—a terrible blight upon the flourishing faunas and floras existing in tertiary times in northern latitudes. The presence of warm temperate plants in Greenland has always excited interest, even to the proposal of very wild theories to account for the genial climate there of preglacial days. It may be that the American *Sequoia* traveled across the bridge anciently connecting Greenland with Iceland and Scotland, and that the renowned cedars of Lebanon are the cousins of their famed relations in California; but the connection has been severed by the ruthless ice-flow, and is not likely to be reëstablished, unless our sun shall carry his sys-

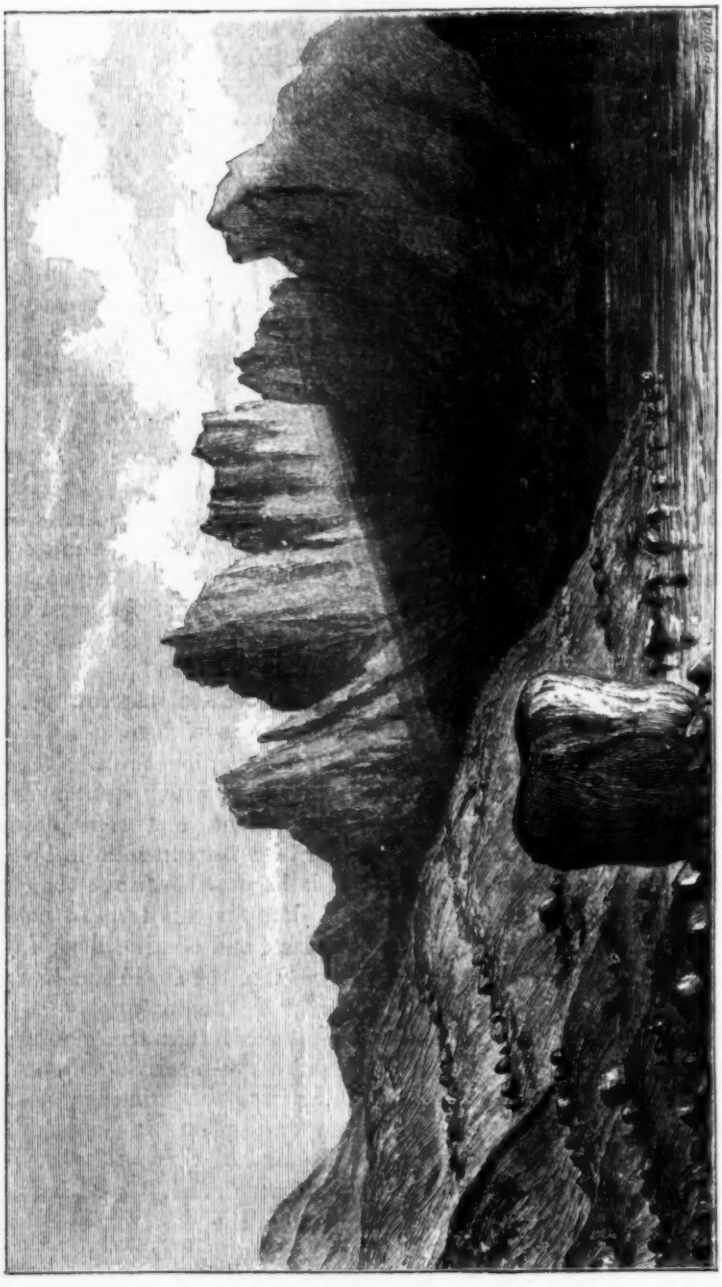


FIG. 9.

ERRATIC BLOCKS OR BOWLDERS RESTING ON GLACIATED ROCKS IN FOREGROUND, COOLIN MOUNTAINS, SKYE.

tem of planets through a much warmer region than the space now encircling us.

Centres of Dispersion.—All existing glaciers flow from higher to lower levels as a rule—the only exception being that already stated, when the ice may be forced up-hill for a short distance. This may be well exemplified in the Alpine glaciers of the present day. These streams of ice all flow from the summits and axes of particular mountains along the valleys, and spread over the neighboring plains. The action is radial—proceeding from a central point or line outward.

FIG. 10.

ALPINE GLACIER.—(H. M. Skae.)

The geologists have concluded that most of the ancient ice-movements in Northern Europe have been from centres of dispersion, like those in Switzerland. Examples are numerous. One of the most interesting is exhibited in Switzerland. The traveler finds there two prominent centres of glacial radiation—the Bernese and the Mont Blanc regions. Glaciers now flow westerly into the great valley of Switzerland and toward the Rhone from the former, and in the latter group the streams discharge upon the Italian plains on the south, and toward the vale of Chamouni on the north. A careful study of the vale of Chamouni shows that ice once filled it to the brim, for the embossed rocks carry striæ even to the height of 5,000 feet.

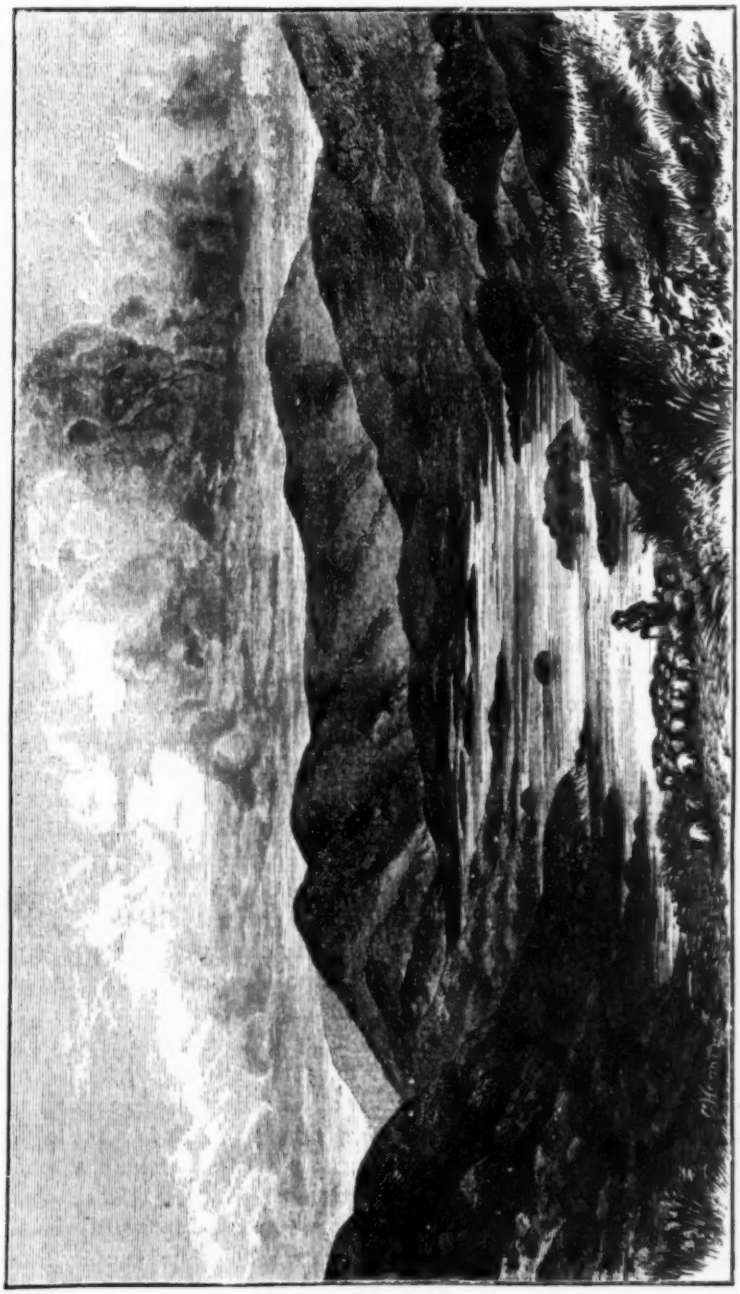
Search for the sources of bowlders proves that large blocks on the southern flanks of the Jura Mountains must have been derived from Mont Blanc, sixty or eighty miles distant. Instead of passing down the Arne at Chamouni, the blocks proceeded northerly toward the Rhone, and thus across the great valley of Switzerland to the Jura. The magnitude of this ancient action equals much of the wonderful glacial phenomena of other districts in Europe, though hardly equal to what may be seen on this continent. But, being satisfied of the former enormous extension of the Alpine glaciers from examination of the striations and the dispersion of blocks, it is easy to generalize and refer similar phenomena in other countries, whose glaciers are extinct, to the same mighty cause.

In Scotland there may have been a centre of dispersion for glaciers from Ben Nevis, another in the south part of the province. In England, one in the Cumberland region; in Wales, one from Mount Snowdon. It is easy to discover the evidence of radial dispersion.

A combination of the glacial and iceberg agencies may be discerned in a map in Mr. Geikie's work, showing the courses of the striæ marked upon the rocks of Scandinavia. They diverge from the central water-shed between Norway and Sweden—part pushing toward Iceland and Scotland, and part directed toward Lapland and the Baltic Sea. The distribution of the bowlders corresponds with these marks. Furthermore, these ice-masses seem to have come in contact with the water of the Baltic, and part have floated over Germany till high land obstructed farther movement, and a part may have been caught by the outflowing Baltic current, carried over the North Sea to the south part of England, and perhaps Iceland. At least, bowlders of Scandinavian origin are common in these regions, and have probably migrated in the way described. On the east shore of Scotland they are plenty; but, between these and those south of the Thames, none have been found, which fact has given rise to the theory of dispersion by means of icebergs through the Baltic.

In years past the prominent topic of discussion in scientific associations has been the character of the ice-movements in the Glacier period. One school has stoutly defended icebergs as the active agent, the other has vigorously insisted upon land glaciation. The example before us seems to require both these agents to account for all the phenomena of this period. Both classes seem to be right, though neither can explain all the facts. Nature's domain is so vast that human intellects do not seem to be capable of grasping the whole truth at once. We are like the mariners who seek to penetrate to the north-pole. They have penetrated a little way beyond Spitzbergen—they have gone nearer the goal through the straits west of Greenland, and have made great exertions in some other quarters. Each party has its theory of the character of the unknown region, as derived from a partial survey. By-and-by the whole of this area will be known, and it

FIG. 11.



LOCH DOON (lower reach), illustrating Rounded Outline of Hills and Slopes produced by Action of Ice. The effect is most marked in certain directions which indicate the course of the ice-masses.

will then appear that each theory had its element of truth. In like manner we are endeavoring to attain to the proper conception of the condition of the earth in the Age of Ice. The whole truth has not yet been discovered. When fully revealed, it will appear far more magnificent and glorious than has now been surmised.

THE PATHOLOGY OF THE PASSIONS.

By FERNAND PAPILLON.

TRANSLATED FROM THE FRENCH, BY J. FITZGERALD, A.M.

III.

IN the former part of this essay we considered the general physiology of the passions: their pathology is no less interesting, and to that we now ask attention. When we reflect that the nervous system of the animal life and the system of the great sympathetic govern all the vital operations, and that the regularity of these latter is absolutely dependent on the orderly performance of their functions by the centres wherein are found the prime springs and the fundamental activities of the animal economy, we conceive at once how countless diseases may arise out of disturbances produced by an abuse or an excess of the passions. Physicians have in all ages reckoned the passions among the predisposing, determining, or aggravating causes of the majority of diseases—especially chronic diseases; for it is a peculiarity of the nerve-substance that it is impaired, and that it spreads abroad the consequences of its impairment, only little by little, and by imperceptible degrees. The work of the passions might be compared to the operations by which an army approaches a beleaguered city: they set about overmastering health and life circumspectly and slowly, but their advance is always sure. A few observations concerning the psychological and physiological disturbances produced by the passions of the moral order, which are the most disastrous in their effects, viz., love, melancholy, hate, anger, etc., will give some idea of the material working of these poisons of the soul.

We may regard love as a neurosis of the organs of memory and imagination, in so far as these two faculties are related to the object of love. The memory in particular seems here to acquire an intensity that is truly extraordinary. In illustration of this point, Alibert states a fact which he observed at Fahlun. As some laborers were one day at work making a connection between two shafts in a mine, they found the remains of a young man in a complete state of preservation, and impregnated with bituminous substances. The man's features were not recognized by any of the workmen. Nothing further was known

than that the accident by which he had been buried alive had occurred upward of fifty years before. The people had ceased to make inquiries as to the identity of the body, when a decrepit old woman came up supported on crutches. She approached the mummified corpse, and in it recognized the body of the man to whom she had been betrothed more than fifty years previously. She threw herself upon the rigid corpse—which was like a bronze statue—wept over it, and manifested intense joy at seeing again the object of her early affection.

As for the imagination, it transcends all bounds, and loses all character of exactitude. The will is no longer mistress of the vital acts. Says Romeo at the tomb of Juliet:

> "Here, here will I remain
> With worms that are thy chambermaids.
> Oh, my love! my wife!
> Death, that hath sucked the honey of thy breath,
> Hath had no power yet upon thy beauty;
> . . . . beauty's ensign yet
> Is crimson in thy lips and in thy cheeks,
> And Death's pale flag is not advanced there."

"I am drawn toward you," writes Mdlle. de Lespinasse to M. de Guibert, "by an attraction—by a feeling which I abhor, but which has all the power of malediction and fatality." The English poet Keats, when dying of consumption, writes thus to a friend: "I am in that state wherein a woman—as woman—has no more power over me than a stock or a stone, and yet the thought of leaving N. is something horrible to me. I am ever seeing her form, which is ever disappearing." This latter fact pertains to the history of hallucinations, and this in turn borders on the history of ecstasies, which are so frequent in religious life; so true is it that love, even mystical and divine, if not confined within the bounds of reason, turns to a kind of mania, which, as we shall see, is full of danger for the general functions of the mind.

Thought draws the sketch of life, but passion adds the coloring of the picture. When this passion is a happy one, the coloring is brilliant and cheerful, and then life is a bright vernal season. But oftener the passion is a painful one, and the color given by it to life is darksome. Melancholy is one of those passions which throw a gloom over a man's life. There is one form of melancholy which is plainly a variety of dementia, and which often comes under the notice of the physician. It is characterized by an incurable sadness, an irresistible love of solitude, absolute inaction, and a belief in a host of imaginary evils that are ever haunting the patient. "My body is a burning fire," wrote a melancholic subject to his medical man; "my nerves are glowing coals, my blood is boiling oil. Sleep is impossible. I endure martyrdom."—"I am bereft of mind and sensibility," writes another; "my senses are gone—I can neither see nor hear any thing;

I have no ideas—I feel neither pain nor pleasure; all acts, all sensations, are alike to me; I am an automaton, incapable of thinking, or feeling, or recollecting—of will and of motion." This form of melancholia is a disease, and not a passion. It is a species of dementia akin to those strange aberrations which go by the name of lycanthropy, lypemania, etc.

The true passional melancholy is that reflex, profound, painful feeling of the imperfections of our nature, and of the nothingness of human life, which seizes on certain minds, torturing them, disheartening them, and making their life one long sigh. This feeling is expressed by the gentle poet Virgil, when he says, "Sunt lacrimæ rerum" (everywhere tears). This is the gloomy thought that haunts the mind of Hamlet, the hallucinatory despair of Pascal, the sadness which broods over Oberman and René, the bitter, heart-rending cry of Childe Harold, the grand desolation of Manfred, the inquietude and the agony represented by Albert Dürer's graver and by Feti's pencil. Melancholy so defined has a place in the depths of the heart of every man that philosophically contemplates Destiny, nor need we seek elsewhere an explanation of the sombre humor which distinguishes men of this kind, and which is witnessed to by those books wherein they convey to us the history of their souls' troubles. If such a humor as this had its source in the common ills of life—in its sufferings, its miseries, and its deceptions—we might understand it perhaps in the case of such men as Swift, Rousseau, Shelley, and Leopardi; but, when we meet with it in such favored geniuses as Byron, Goethe, Lamartine, and Alfred de Vigny, we are forced to acknowledge that, in men of the higher stamp, its cause must be the pain they feel on seeing that they cannot slake their ideal thirst.[1] Such is the melancholy which we may call the *philosophic*.

Besides this, there is another form of melancholy which proceeds from better-defined causes, i. e., from the common griefs and vexations of life. Reverses of fortune, balked ambitions, and disappointments in love, are usually the causes of this kind of sadness, which, being far more active than purely philosophic sadness, often gives rise to organic disorders of the most serious kind. Albert Dürer succumbed to the vexations caused him by his wife. Kepler died the victim of the afflictions heaped upon him by Fate. Disappointment in love is one of the most frequent causes of melancholy. This it is which harassed and tortured Mdlle. de Lespinasse—which troubled and worried the chaste soul of Pamela: it was the death of the beautiful Genoese, Tommasina Spinola, when she heard of Louis XII.'s illness, and of Lady Caroline Lamb, when she went home after the fu-

[1] "What from this barren being do we reap?
Our senses narrow and our reason frail,
Life short, and truth a gem which loves the deep."
—"*Childe Harold*," iv., 93.

neral of Byron. These two women had lived years and years, the one preserving in the depths of her heart the calm despair of an impossible love, the other the bitter recollection of a love that was spurned; but neither of them could outlive the affliction of seeing the object of her affection taken away by death. There are some cases in which the resistance is not of so long duration, and where the ravages of passion are such that the organism becomes dislocated with fearful rapidity. Indeed, it is no rare thing for a physician to be summoned to a patient who is wasting away with sadness and dejection. No organic cause can be discovered to account for the malady; the usual remedies are of no avail; the patient does not mend, and usually keeps the secret of his griefs to himself. In such cases the physician should always strive to discover whether there is any passion of the soul which produces this disorder of the functions, and makes his remedies of no effect. Usually such a passion exists. Thus it was that the physician Erasistratus discovered that Antiochus loved his step-mother, Stratonice. Boccaccio likewise tells of a physician who by chance detected the true cause, previously unknown, of the complaint with which a certain young man was suffering; whenever a young female cousin of the patient entered his room, his pulse beat quicker. It often happens that the melancholic becomes incapable of bearing his afflictions, or of waiting for death to relieve him. This is the origin of suicide. The history of medicine and literature is full of narratives, real or fictitious, of suicide determined by an unfortunate passion. While we admire what is touching and dramatic in such narratives, we cannot fail to see that suicide is *in se* a fact of the morbid kind. Its cause is a total aberration of the instinct of self-preservation; and, as the latter has its seat in a certain part of the brain, we are authorized in locating the cause of suicide in a cerebral disorganization, brought about more or less rapidly by certain more general changes in the economy.

Similar changes are produced sooner or later under the influence of resentment, hate, and anger. Resentment is a secret passion which draws its plans in silence. Hate is taciturn, or finds utterance only in imprecations. Anger has its crises. Whereas resentment is disquieting, hate painful, and anger distressing, revenge is a kind of pleasure. It has been compared to the feel of silk, to indicate at once its imperious nature and our gratification in appeasing it. When anger and the desire of revenge distend the veins, flush the face, stiffen the arms, brighten the eyes,[1] bewilder the mind, and lead it to the commission often of criminal acts, the soul feels a sort of delight, but it is of short duration; and the momentary excitement is followed by a pro-

[1] In his admirable studies on the "Expression of the Emotions," Mr. Darwin notes a characteristic expression of fear, rage, and anger, not found in man, though it appears in all animals—viz., the erection of the hair and feathers. This phenomenon, which is analogous to that of *goose-skin* in man, is produced not only by passional influences, but

found depression whose effects, if oftentimes repeated, differ not from those of concentrated resentment or pent-up hate. The man who is given to outbursts of anger is sure to experience a rapid change of the organs, in case he does not die in a fit of rage.

Death under such circumstances is of frequent occurrence. Sylla, Valentinian, Nerva, Wenceslas, and Isabeau of Bavaria, all died in consequence of an access of passion. The medical annals of our own time recount many instances of fatal effects following the violent brain-disturbance caused by anger. The symptoms usually are pulmonary and cerebral congestions. Still such fatal accidents as these are exceptional: as a rule, the passions of hate and anger deteriorate the constitution by slow degrees, but surely.

How, then, do we explain those morbid phenomena which have their origin in misplaced affection, in disappointed ambition, in hatred, or in anger, and which culminate either in serious chronic maladies, or in death or suicide? They all seem to start from an impairment of the cerebro-spinal centres. The continual excitation of these by ever-present emotions determines a paralysis of the central nerve-substance, and thus affects its connections with the nerves extending out to the various organs. These nerves next degenerate by degrees, and soon the great functions are compromised. The heart and the lungs cease to act with their normal rhythm, the circulation grows irregular and languishing. Appetite disappears, the amount of carbonic acid exhaled decreases, and the hair grows white, owing to the interruption of the pigmentary secretion. This general disturbance in nutrition and secretion is attended with a fall of the body's temperature and anæmia. The flesh dries up and the organism becomes less and less capable of resisting morbific influences. At the same time, in consequence of the reaction of all these disturbances on the brain, the psychic faculties become dull or perverted, and the patient falls into a decline more or less complicated and aggravated by grave symptoms. Under these conditions he dies or makes away with himself.

Two organs, the stomach and the liver, are often affected in a peculiar and characteristic way in the course of this pathological evolution. The modifications produced in the innervation, under the influence of cephalic excitement, cause a disturbance of the blood-circulation in the liver. This disturbance is of such a nature that the bile, now secreted in larger quantity, is resorbed into the blood instead of passing into the biliary vesicle. Then appears what we call jaundice or icterus. The skin becomes pale, then yellow, owing to the

also by cold. Darwin explains this *horripilation*—as it is called—by the action of the nervous system on certain minute involuntary muscles called *arrectores pili*, recently discovered by Kölliker, in connection with the capsules at the base of the separate hairs and feathers. The excitation of these little muscles, which are very numerous over the entire body, determines, by reflex contraction, the erection of which we speak, and affords one of the most characteristic signs of fright, rage, and anger, in animals.

presence in the blood of the coloring matter of the bile. This change in the liver is usually developed slowly: sometimes, however, jaundice makes its appearance suddenly. Villeneuve mentions the case of two youths who brought a discussion to an end by grasping their swords; suddenly one of them turned yellow, and the other, alarmed at this transformation, dropped his weapon. The same author speaks of a priest who became icterical (jaundiced) on seeing a mad dog jump at him. Whatever may be said of these cases, we must reckon painful affections of the soul among the efficient causes of chronic diseases of the liver.

The digestion, says the author of a work published some years ago, is completely subjected to the influence of the moral and intellectual state. When the brain is wearied by the passions, appetite and digestion are almost gone. Whatever causes grief or fright affects the stomach more or less. In times of epidemic, or of civil war, and in all social conjunctures when any extraordinary peril threatens the masses, dyspepsia becomes more frequent, and assumes a more serious aspect. This affection commonly prevails amid the various symptoms of depression and decline produced by moral suffering. The direct pathological consequences of disordered nutrition, whose chief symptom is dyspepsia, are of the most serious nature, and there is no doubt that among them we must reckon cancer. Hence it is that Antoine Dubois located the cause of cancer in the brain.

IV.

As a vibrating chord determines vibration in a neighboring chord, so a passion produces in those who are the witnesses of it a passion or a tendency to a passion of the same kind. The infant by a smile responds instinctively to its mother's smile, and it is difficult to contemplate attentively the portrait of a smiling person, especially if we observe that the face wears a smile, without our own faces assuming a like expression. "We cannot," says Leon Dumont, "reflect on any mode of expression, but our countenances will have a certain tendency to conform itself to it." *A fortiori* it will so conform itself when, instead of merely reflecting on the expression, we see it. Yawning, hiccoughing, and sighing, are as contagious as laughter.

All passions, whether good or bad, are contagious. Esquirol seems to have been the first to discern and characterize moral contagion, which he defines to be that property of our passions whereby they excite like passions in others who are more or less predisposed to them. The contagion of good example is manifest, and it is certain that the worship of the saints is one of the wisest and most powerful instrumentalities devised by the Catholic religion. Unfortunately, depraved passions too have their imitators, and in this case the imitation is so prompt, so thorough, and in some sort so automatic, as often to appear irresistible. An able psychological physician, M. Prosper

Despine, who has bestowed profound study on this subject, shows, from a very large number of instances, that when a crime surrounded with dramatic circumstances is published abroad, and made matter of general comment, a certain number of similar crimes will be committed soon afterward. Minds that are not fortified, by a strict morality and a good education, against the allurements of such examples, and whose slumbering passions only await the occasion that will stir them up, are spurred on and decided to act by the bustle and the parade made about the hero of a criminal trial. M. Despine's statistics on this painful subject are exceedingly curious and conclusive. Now it is some peculiar form of murder, again a new process of poisoning, anon, some original way of disposing of a corpse, that gives occasion to grim plagiarisms with all the circumstances identical. In a word, all criminal acts proceeding from hate, revenge, and cupidity, always summon forth in certain individuals a spirit of emulation. Hence it were advisable absolutely to forbid the publication, in popular prints, of criminal trials whether real or imaginary, and to interdict the performance of plays wherein wickedness and crime are portrayed for the gratification of the spectator's morbid curiosity. M. Despine's suggestion with regard to this matter will be approved by physicians and hygienists, who are all agreed that writings and plays of a certain class are to be reckoned among the causes which conduct so many wretches to the galleys, the morgue, and the mad-house. When we disseminate examples of outrage and disorder, we must not be surprised if we find a harvest of crime and insanity. Let us then heartily second the suggestion we speak of, and which M. Bouchut authoritatively formulates when he says that, instead of feasting the public with recitals and plays so dangerous to the common weal, we should rather found a moral pest-house to which should be committed, so soon as they make their appearance, those rascalities whose contagiousness is now beyond question.

Besides the contagion of those passions which end in crime, there is also the contagion of those passionate states which terminate in suicide. Epidemics of suicide are frequent in history. The instance of the young women of Miletus, as told by Plutarch, is familiar. One of them hung herself, and immediately several of her companions made away with themselves in the same manner. To stay the progress of this redoubtable frenzy, the order was given to expose the naked bodies of the suicides in the market-place of the city. An ancient historian of Marseilles records an epidemic of suicide which raged among the young women of that place. In 1793 the city of Versailles alone offered the spectacle of 1,300 voluntary deaths. In the beginning of the present century a suicidal epidemic destroyed large numbers of people in England, France, and Germany, the victims being young persons who had conceived a disgust for life, from the reading of melancholy romances, coupled with precocious over-in-

dulgence in pleasures. A still stranger epidemic is that of infanticide, which prevailed in Paris at the beginning of this century, after the newspapers had published the history of the Cornier case. Madame Cornier, under the influence of infanticidal monomania, had murdered her child under circumstances of such a kind as to make an impression on a certain number of mothers, so that, though excellent women and sincerely attached to their children, they were seized with a desire to get rid of them. They did not yield to the temptation, but the circumstance of their being attacked with such a mania excited much surprise among medical men.

It will not be uninteresting, if to these curious phenomena we append the facts of nervous contagion to which M. Bouchut called the attention of physicians some years ago. It had long been known, especially since the time of the famous *convulsionnaires* of the St.-Médard Cemetery, that some neuropathic states are multiplied by instinctive imitation; but M. Bouchut shows that facts of this kind are far more common than has been supposed, and the work wherein he describes them adds a new and a dramatic chapter to the strange history of nervous aberrations. One of the first cases given by M. Bouchut is as follows—it was observed at Paris in 1848, in a shop where 400 work-women were employed: One day one of these work-women turned pale, lost consciousness, and fell to the floor, her limbs convulsed, and her jaws set. Within the space of two hours 30 of the women were seized in the same way. On the fourth day 115 were affected, the symptoms in all cases being the same, viz., suffocation, prickling sensation in the limbs, vertigo, dread of sudden death, followed by loss of consciousness in the convulsions. A similar epidemic was observed in 1861 among the young girls of the parish of Montmartre, who were preparing for the first communion. On the morning of the first day of the *retraite*—or preparatory season of religious seclusion—while at church, three of them became unconscious, and were seized with general convulsions. The following day the same symptoms appeared in three other girls. Still others were attacked on the third day. On the fourth, the communion-day, 32 were seized in the same way. On the fifth, confirmation-day, as the archbishop approached, 15 girls were seized with convulsions, uttered a shriek, and fell to the floor unconscious, when the prelate was about to confirm them. Thus, in the space of 75 days, 40 girls out of 150 manifested identical nervous disorders.

The various hallucinational, ecstatic, and spasmodic states, transmitted and multiplied by example, play an important *rôle* in mediæval history, particularly among the religious orders. There is the closest analogy between the accounts handed down to us by the writers of those times and the observations of physicians published in our own day. As concerns the question of treatment, we possess hardly any save moral remedies; and the success attending the employment of

these shows well the purely nervous character of these singular affections. We read of Boerhaave staying an epidemic of hysterical convulsions in a boarding-school by threatening to burn, with a red-hot iron, any of the girls who should be attacked. Practitioners in our own time adopt analogous processes and artifices to conquer those passions which degenerate into morbid states. They strive to inspire the patient with a passion different from that which possesses him, and to fix his attention on subjects disconnected with those which occupy his mind.

This style of physic—this moral therapy—requires infinitely more tact and discernment than the application of the usual remedies of the pharmacopœia. Nor is it in our medical schools that young men, who intend to practise the healing art, can learn to diagnose and to treat those maladies wherein the soul wrecks the body. This is a vocation which requires profound personal study and observation, and wherein the student would do well to draw on a source too much overlooked in our times, viz., those old authors who treat questions of this kind. The young physician will find equal profit and delight in studying those profound connoisseurs of the human mind, La Chambre, Stahl, Pinel, Hoffmann, Bichat, Tissot, Richerand, Alibert, Georget. From them the student will not only learn how to judge wisely of the passions of others and of the best means of treating them, but will also get sage counsels for the government of his own. There he will see that there is nowhere perfect health, save when the passions are well regulated, harmonized, and equipoised, and that moral temperance is as indispensable to a calm and tranquil life as physiological temperance. He will see that, without going the lengths of stoicism—in which there is more pride than wisdom, more ostentation than virtue—the noblest and the most desirable state for the mind and body alike is equidistant from all extreme passions, i. e., situated in the golden mean. And this conviction that regular living and moderation in material as in emotional life are the secret, not, indeed, of happiness—which is nowhere in this world—but of serenity and security, he will strive to spread abroad as being the most useful precept of the medical art. If it is your desire that your circulatory, respiratory, and digestive functions, should be discharged properly, normally, if you want your appetite to be good, your sleep sound, your humor equable, avoid all emotions that are over-strong, all pleasures that are too intense, and meet the inevitable sorrows and the cruel agonies of life with a resigned and firm soul. Ever have some occupation to employ and divert your mind, and to make it proof against the temptations of want or of desire. Thus will you attain the term of life without overmuch disquiet and affliction.—*Revue des Deux Mondes.*

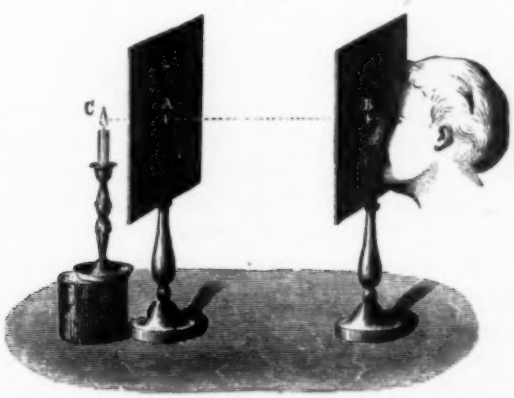
IMAGES AND SHADOWS.

By W. J. YOUMANS, M. D.

SO much has been said lately of the wonders of spectrum analysis, that we are very apt to forget the other and equally marvelous properties of the agent by which it is produced. Spectrum analysis is a rare and curious experiment, but the more familiar effects of light which we daily experience are really just as wonderful, if we will but pause to reflect upon them. Science means knowledge, and the science of optics embodies our knowledge of light; but how much, after all, do we know of it? A great deal, undoubtedly, of its modes of action, but very little, if any thing, of its nature. We have an hypothesis or supposition about it, and work out ingenious conclusions, logically and experimentally, and say that they are proved; but how far are we from comprehending them.

That light moves at an amazing velocity, is shown in several ways; and all the methods bring us to about the same results which are expressed in numbers and are demonstrably true; but what finite mind can enter into the meaning of the statement that the luminous ray moves forward at the rate of 185,000 miles in a second of time? Between the two ticks of a second's pendulum, we are told that light

FIG. 1.



RECTILINEAR PROPAGATION OF LIGHT.

would pass round our globe seven and a half times. But who has a notion even of the dimensions of our globe? The number of thousands of miles through it and around it have been calculated, and the calculations harmonize with the whole body of astronomical knowledge; but we can form no adequate conception of such magnitudes. We patch together different shreds of our mental experience of large

things, and construct a symbolic idea which represents our planet, but we never grasp the reality in the immensity of its proportions.

Light is a force, and science holds that it is made up of impulses. Nature has been shown to conform all kinds of dynamical effects to rhythmical pulsing, or wave-like action and the impulses of light are held to be of the same kind. There are, at any rate, measurable effects which are unequal in the different colored lights, and the scale has been determined. In an inch of violet light it is shown that there are no less than 57,000 waves, a statement in which there is nothing extraordinary or impossible, as Nobert, the German optician, is in the habit of ruling his microscopical test-glasses at rates all the way from 100,000 to 200,000 per inch. But, when we are told that the ray enters the eye at the rate of 185,000 miles per second, and—as each inch contains 57,000 waves—that when we are looking at a violet object there are 699,000,000,000,000 beats upon the retina each second, the statement baffles all imagination: we may accept, but cannot understand it. In the attempt to penetrate the nature of light we are lost in the mysteries of the infinite. Yet the modes of its action have been determined, and they furnish the most splendid example we know of the inflexibleness and exactitude of what are called the laws of Nature.

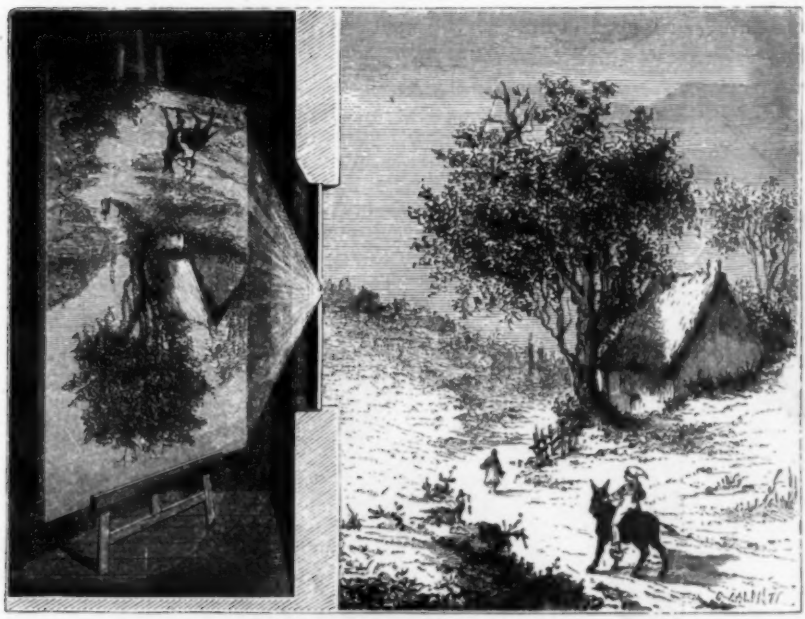
FIG. 2.

IMAGE FORMED BY A HOLE IN A CARD.

Man is placed in the midst of the universe, and is designed to have knowledge of it. He is impressible to outward agencies, and possesses a grand cerebral treasury-house for storing up these external impres-

sions. Touch, taste, smell, and hearing, are the senses by which he becomes acquainted with many properties of things immediately around him; but the universe is reported to him through the sense of vision and by the agency of light. Somehow, in their mysterious nature, the luminous rays from all sources, distant and remote, effect a change in the nerve-structure of the eye by which impressions are transmitted to the brain. Into that mode of action we cannot now enter, but will confine our attention at present to the property of light by which luminous images are produced. For it is, after all, the images of things we have to deal with. We know the external world in its distances, forms, and colors, because its visible objects are all duplicated in the eye. The cloud, the landscape, the cathedral, that excites our thought and kindles our feeling, is, in each case, but a picture recreated from the external object by the agency of light.

FIG. 8.



INVERTED IMAGE OF LANDSCAPE.

The first property, or law, of light, upon which the production of images depends, is simply that it moves in straight lines through any uniform medium that it can traverse. We are all familiar with the general fact that the path of light is rectilinear, but it may be accurately proved by a very simple experiment.

Two screens, A, B (Fig. 1), each pierced with a minute hole, are so arranged that the apertures are in a line with the flame of a candle, C. An eye, placed in this line behind the screens, is then able to see

the flame; but, if the eye, the candle, or either screen, be slightly displaced to the right or left, the ray is interrupted, and the flame becomes invisible.

This propagation of light in straight lines, though the first condition of the production of images, is not the only condition; for, in that case, the images of illuminated objects would be repeated everywhere, and, when the blinds were opened, a picture of the landscape might be thrown, through the window, upon the opposite wall of a room. For the formation of an image, the rays of an object must be collected and passed through an aperture. This is shown by a simple experiment illustrated in Fig. 2. A card is pierced with a large pin-hole and held between a candle and screen, when an image of the candle will be formed upon the screen in an inverted position. That the image must be upside-down is evident, if the rays take a straight course. A line from the top of the candle-flame through the puncture is prolonged to the bottom of the image, and another, from the bottom of the flame, crosses the first at the aperture, and strikes the top of the

FIG. 4.

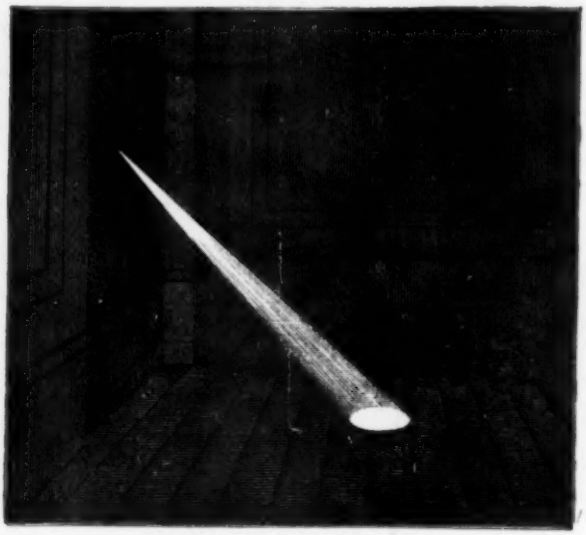


IMAGE OF SUN UPON THE FLOOR.

image. A line from the centre of the candle passes straight through and strikes the centre of the image, while lines from the two sides of the flame cross again, and are prolonged to the opposite sides of the image. Thus, as each point upon the screen receives only the light from a corresponding point of the flame, the image repeats the object in outline, color, and brightness, though in a reversed position.

This principle may be applied on a larger scale. Let a room be made quite dark, and a white screen be placed opposite a small hole

in the shutter. There will then be formed upon the white surface an inverted picture of the external objects, as shown in Fig. 3. They will appear of the natural colors, and the outlines will be sharper in proportion as the hole is smaller.

When the sun shines through a small orifice into a darkened room, a cone of rays is produced, as everybody has observed, by lighting up the particles of dust which are scattered in its course; for, if the air were quite clear, the track of the rays would be invisible. In this case an image of the sun is formed upon the floor or opposite wall by

FIG. 5.

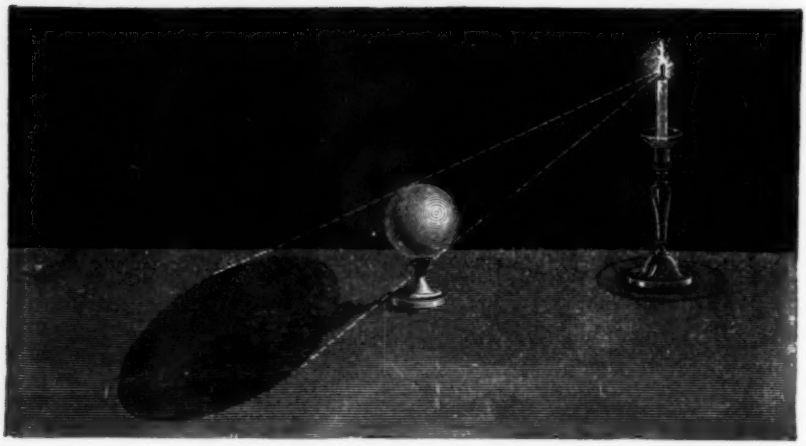
IMAGES OF SUN FORMED BY FOLIAGE.

the crossing of the rays through the aperture, exactly in the manner of the production of the candle-image and the landscape-picture just described. The best condition for the formation of such an image is when the sun is low, and there is a white wall opposite to receive it; the image is then perfectly circular. But if the light falls upon the floor, as represented in Fig. 4, the cone of rays produces an oblong or elliptical image; the deviation from an exact circle depends upon the angle which the cone of rays makes with the floor. Such an image

may often be made instructive in observing solar phenomena. By closely examining it, it is sometimes possible to detect the presence of spots on the solar surface. Solar eclipses may be watched in the same way. As the moon gradually encroaches upon the sun's disk its progress can be traced by a corresponding change in the form of the image, which resembles that of the uneclipsed portion of the solar surface. In such observations, however, it will be remembered that the course of the movement is always reversed. It was in this way that the transit of Venus was first observed by Jeremiah Horrocks, November 24, 1639. He had calculated the time, which fell upon Sunday morning. He arranged his room for the observation, and then went to church, as he did not wish any secular interests to interfere with religious devotion. It is very probable, however, that Venus was mixed up with his devout meditations, for he hurried back from service, and was delighted to find that his calculations were verified, as the planet was already far advanced in its passage across the sun's face.

We are all familiar with similar images of the sun, of a round or oval outline, formed upon the ground where his rays shine through small openings in the foliage of trees, as illustrated in Fig. 5.

FIG. 6.



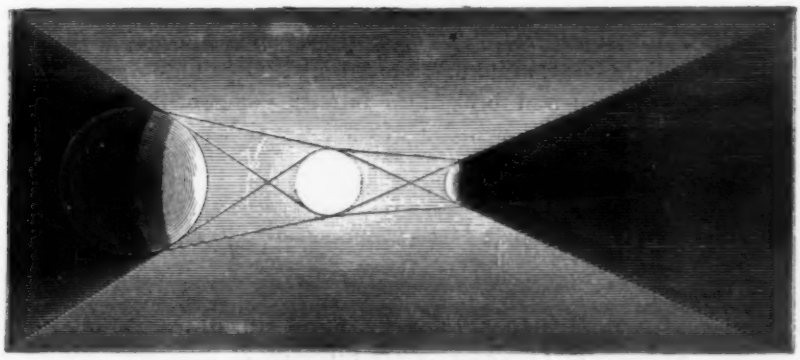
FORMATION OF A SHADOW.

The same property, that is, the rectilinear propagation of light, gives rise to a reverse effect, or a sort of dark image or shadow, although a shadow depending upon the absence of light is of course not properly an image. "Let the source of light be a luminous point, and let an opaque body be placed so as to intercept a portion of its rays (Fig. 6). If we construct a conical surface touching the body all round, and having its vertex at the luminous point, it is evident that all the space within this surface on the farther side of the opaque

body is completely screened from the rays. The cone thus constructed is called the shadow-cone, and its intersection with any surface behind the opaque body defines the shadow cast upon that surface. In the case which we have been supposing—that of a luminous point—the shadow-cone and the shadow itself will be sharply defined."

Actual sources of light are not, however, mere points; they have finite and variable dimensions, and this complicates the effect in the geometry of shadows. These effects are well illustrated by the diagram (Fig. 7). Let the central sphere represent a source of light placed between two opaque spheres, one larger and the other smaller than itself. We shall then have two kinds of shadow, the total shadow or *umbra*, and the partial shadow or *penumbra*. If the opaque sphere, seen at the right in the diagram, be smaller than the luminous body, the umbra terminates at a finite distance depending upon the relative magnitudes and the proximity of the two bodies. If the opaque body is larger than the source of illumination, as illustrated in the left portion of the diagram, the cone of the umbra is projected to an infinite distance. The penumbral cones represented

FIG. 7.



UMBRA AND PENUMBRA.

by a lighter shading, it is seen, are wider than the cones of total shadow, and include them. It will be noticed that all points lying within the penumbral cones are excluded from the view of *some portion* of the luminous body, and are thus partially shaded by the opaque bodies. Points that are very near the outer boundaries are very slightly darkened, if near the total shadow they are almost completely shaded. The penumbra is, therefore, not a uniform shadow, but gradually fades into darkness from its outer limit to the total obscuration of the umbra. It follows from this that the shadow of an opaque body falling upon a screen will not have a sharply-defined edge, but will show a transition from total shadow to the complete absence of shadow. To have the shadow clean and sharp at its edge,

it would be necessary to have the source of illumination a mere point. Of course the effect of such abrupt transitions from perfect illumination to total darkness, if it were the plan of Nature, would be most inconvenient and painful, if not destructive to the eyes. We are protected from this by the phenomena of double shadows, and the gradual passage from darkness to light, although each luminous ray moves undeviatingly in its straight line. Light cannot turn corners like sound. This is explained by the excessive shortness of the luminous as compared with sonorous waves. Sound-waves are so large that they flow around objects in the air, and consequently cast but feeble shadows, although Deschanel (from whose admirable work on "Natural Philosophy" our cuts are borrowed) states that Collodon, in his experiments on the transmission of sound through the water of the Lake of Geneva, established the presence of a very sharply-defined sound-shadow in the water behind the end of a projecting wall.

It is necessary to say, however, that the foregoing statement that light cannot turn corners is only true in the common and general experience of it. If we carry our experiments with light down to so fine a point that we reach the dimensions of its waves, it is then found that they are capable of bending round obstacles. If sunlight be allowed to pass through an exceedingly fine slit, and then to fall on a screen of white paper, colored bands appear, called diffraction fringes; that is, the white light, in its passage through the minute opening, has been interfered with and broken up into its component colors. We have here, however, a new order of effects which will require to be separately considered.

VIVISECTION.

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IN the following pages I propose to inquire whether it is desirable that physiologists should continue the practice of what is commonly called vivisection, to which they have hitherto been accustomed. By vivisection I understand the operating with cutting instruments or by other means on the still living bodies of animals. The word "living" requires, perhaps, some further definition. In the long series of changes through which the body of a living animal passes, from full functional activity to complete decomposition, there are three chief stages, each of which may be arbitrarily taken as the end of life. There is the time at which consciousness is lost, the time at which the breath stops and the heart ceases to beat, and the time at which the muscles become rigid with the death-stiffening. The succession of the three events is always in the same order, but the interval of time be-

tween any two of them varies within very wide limits. For our purposes it will perhaps be best to take the second as marking the end of life, to say that an animal is still alive so long as the heart is beating, and air enters into and issues from the chest.

It is very desirable that a discussion, the decision upon which must be of the utmost importance to physiology at least, should not be turned aside to any false issues. The question whether vivisection is a bad thing is in no wise settled by asserting that there are many things equally bad. Thus, to say that the evil wrought upon animals in the name of science is but a flea-bite compared to that done in the name of sport, is simply to bring forward a *tu quoque* argument of no real worth, except to stop the mouths of particular opponents. When an ardent sportsman, or when one, no sportsman himself, but having a theoretical admiration of the pleasures of the field, declaims against vivisection, it may be worth while to remind such a one of some of the agonies of sport—of the scenes which accompany a *battue* or a pigeon-match; of wounded birds dragging their maimed bodies to some hidden covert, there to die a lingering death; of the piercing squeals of the hunted hare; of the last moments of the brave fox, when, after a fruitless struggle, the time comes for his living body to be torn by the pursuing hounds; to ask him how often a living object of sport is by some purposeful, sudden blow, humanely killed "to put it out of its misery;" to suggest to him, as a matter of reflection, that, had we any satisfactory measure of pain, it would be found that all the pain which physiologists have caused, since their science began, is less than that which the animal creation has suffered in the field from the hands of the members of the two Houses of Parliament since the last general election. It may be of use to say this to a sportsman; but vivisection is not thereby justified. It is no use saying it at all to those who are now agitating this question. They are equally opposed to cruelty in sport as to cruelty in science; but they are also wise in their generation. They see that there is far more hope of putting down the one than the other. Biologists and physiologists are at the present moment clearly in disrepute. To call them atheists, is to show one's self a man of spirit and intelligence. Following out their own science, along the path Nature has pointed out to them, they have run counter to many established opinions and cherished views. Divorced by the divergence of their respective methods in large measure from the mathematicians and physicists, to whom orthodoxy is easy, accused of materialism, active in the support of Darwinism and evolution theories, believed by the many to have no faith—their position not a little resembles that of the Jews in the middle ages; they are just in the condition in which the accusation of cruelty is most tellingly made and most readily credited against them by a vulgar public. This the opponents of vivisection know full well; and therefore it is against the physiologists and not against the pigeon-

shooters that they make their complaint. They are even willing, at the present, to use the latter against the former. By-and-by, if they are successful in this, they will move against sport, on the ground that it is far more cruel and has far less justification than the vivisection which has been done away with.

Nor is it any use to tell a far larger class, the eaters of meat, that the pain which physiology has caused since the time of Galen is far less than that which in any one week is caused in butchers' shambles in providing flesh to fill the mouths of the people of London.

Nor is it, on the other hand, any use to say that because many physiologists are kindly, humane men in private life, therefore the accusation of cruelty brought against them must be false. I know a physiologist who, after a day spent in experimental work, may be seen sitting in the evening with a favorite cat on his lap, an old dog by his side, and a new one at his feet; but I would not therefore guarantee that he had not been cruel in the morning. He might be an angel in the bosom of his family, but a demon in the laboratory. I know a physiologist, of whom his friends have said that, had he not been so amiable, he might have made a noise in the world, and yet who at the present moment is being accused of brutal cruelties. I feel that the accusation might be true.

Nor is it of any use to say, though it may be said with perfect truth, that a great deal of the present agitation against vivisection is one of the many fruits of a mawkish sentimentalism which is stealing over the present generation, and by a lessening of manliness is curtailing the good effects of increased enlightenment. The foolish of this world are often used to correct the wise; and actions brought about by a wrong sentimentalism may be in themselves right and good.

The question whether it is desirable that man should continue to inflict the pains of death, or pains without death, on other animals, and, if so, within what limits, is one which must be argued out on its own merits alone, and the discussion of it will not be advanced by irrelevant considerations such as these on which we have dwelt.

There are two aspects of the inquiry—one from the side of man, the other from the side of the animal. Let us first consider the question from the point of view of the animal.

We have to determine the principles which govern or should govern the conduct of man toward animals. One broad principle may be briefly stated: Unless man destroys animals, animals would soon destroy man. Mr. Tennyson has told us—

> "Nature is one with rapine, a harm no preacher can heal;"

and Mr. Darwin has shown that the lives of all living beings are shaped by "the struggle for existence." Man's life is a struggle for existence with his fellow-men, with living animals and plants, and with

the lifeless forces of the universe. The very conditions of his existence lay upon him the burden, and in so doing give him the right, to use the world around him, the lives of animals included, to aid him in his strife. Imagine the results of forbidding man to take away the lives of animals. Suppose, for instance, the whole human race were to form itself into a Society for the Prevention of the Destruction of Tigers. How many generations would pass before "the last man" provided a tumultuous crowd of tigers with the last human meal?—possibly the indefatigable secretary of the Society sealing with his death his loyalty to the cause. Or, since tigers, like man, are carnivorous, and might therefore be supposed more worthy of death than herbivorous creatures, let us suppose the efforts of the Society to be directed toward the preservation of sheep. How many generations would pass before the face of the earth were covered with woolly flocks, and man were driven to lead a laborious, frugivorous, arboreal life on the tree-tops, or to earn a scanty subsistence on resuscitated *Pfahlbauten*, as being the only places where the necessities of the sheep would permit him to dwell? Did the reader ever by chance descend, at early dawn, into the kitchen and watch the convulsive agonies of a writhing heap of cockroaches drowning in the watery trap set for them by the cook overnight? What a scene of unutterable woe is that when judged from the stand-point of the cockroach! But, if man were to deny himself the right of vivisection or vivipression over the vermin which infest his home and bed, what would come of it?

To be serious: man, if he is to live and prosper, *must* kill other animals. It is a duty laid upon him by the nature of things; a duty, and therefore a right. Self-preservation demands it. But what do we mean by self-preservation? Can we draw a line and say that he is justified in slaying an animal for this purpose and not for that? We can only do so by applying the test of whether the death of the animal is useful to him or not. Whenever or wherever the death of an animal is of advantage either to himself or to the human society of which he is a unit, he is justified in slaying that animal.

The success of the human race in the struggle for existence depends on man's being well fed; man is therefore justified in slaying and eating a sheep. The success of the human race in the struggle for existence is dependent on knowledge being increased; man is therefore justified in slaying a frog or a rabbit, if it can be shown that human knowledge is thereby enlarged.

Death is in itself painful. It is only by special means that the pangs amid which the ties of life are loosened can be done away with. The slaughter of an animal is therefore of necessity painful, except in the special cases where means have been taken to do away with pain. In ninety-nine cases out of a hundred, when an animal is slaughtered by man, it is the death of the animal which benefits man, the pain itself which accompanies the death does him no good at all. While

justified, therefore, in killing the animal, he is not justified in causing it pain. He is bound, in fact, to kill the animal in such a way as to cause as little pain as is consistent with his own interest. The death of a sheep in a butcher's slaughter-house is painful; but men cannot therefore be said to do wrong in killing a sheep for food. They kill it with as little pain as is under the circumstances possible. They could not make the pain less, except by the introduction of elaborate and costly methods which would probably ruin the butcher or spoil the meat, or at least, in the present state of our knowledge and of the market, do damage to the interests of mankind. The death of an ox, again, is more painful than that of a sheep; but men do not therefore feel bound to live on mutton alone. They consider that the advantages of a mixed diet of beef and mutton justify them in inflicting that additional quantity of pain which is suffered whenever an ox is felled.

In short, this, under one aspect, is a selfish world. The struggle for existence is its guiding principle. If we believe that man is to govern the world, and he must either govern or succumb, then we must be prepared to use animals selfishly, if you please to call it so—to use animals for our advantage—to kill them when we have need of their deaths—to kill them with pain when the pain is for our benefit; and, inasmuch as the greater includes the less, to inflict pain without death where their pain does us good.[1] Our good is, in fact, the rule of our conduct toward animals. Whenever an animal is killed by man, or suffers pain at the hand of man, without benefit to man, or where the same benefit could be gained without the death or without the pain, then the death or the pain can be no longer justified. The man who inflicts them is a cruel man; he no longer does good, but harm, to humanity, and humanity ought to stop his hand.

I feel that I ought almost to apologize to the reader for having spent so much of his time over what are almost truisms; but so many absurd statements are continually being made, and so many whimsical ideas broached, that it seemed desirable to have a clear understanding concerning the principles which should guide our general conduct toward animals before discussing the special subject of vivisection.

We have now to inquire whether the deaths and pains which the word vivisection implies are, or have been, wrought for the benefit of mankind, inasmuch as they have led to knowledge and power which could not otherwise have been gained; or whether they had not been wrought for the benefit of mankind, inasmuch as they have not led to knowledge and power, or the power and knowledge might have been gained in some other way, or, being gained by many deaths and much pain, have been so small that mankind could well have done without

[1] Some writers have urged that while man is perfectly justified in *killing* any number of animals, he is not justified in causing *pain*. From the point of view of the animal this is simply a grotesque absurdity; from the point of view of man we shall have to speak of it later on.

them. I introduce the word death as well as pain, because, in spite of the etymology of the word, and the fact that vivisection suggests to the public mind pain only, and not death at all, the truth is, that in at least the great majority of cases vivisection does or ought to mean death only, and not pain at all. In the minds of those ignorant of physiology—and they are foremost, if not alone, in blaming vivisection—much confusion has arisen from the different meanings attached to the words "life" and "living." I alluded to these in the beginning of this paper. To many such it is perhaps a revelation to learn that an animal may be kept alive—that is, with its heart in full working order, and its respiratory movements continuing with perfect regularity—for hours and hours after all signs of consciousness have disappeared. All operations performed on such an animal would come under the term vivisection; but, in the total absence of all signs of consciousness, it would be absurd to speak of pain. It would perhaps be a still greater revelation to such to learn that a frog, at a later stage in the series of events which we class together as death—when its brain and spinal cord have been instantaneously destroyed by an operation the pain of which may be said to be infinitesimal, and its heart removed at a time when feeling is impossible—may yet be made by proper means to kick and jump and move its body about in almost all possible ways. Any operation performed on the body of such a frog would by many be still called vivisection; but, to speak of such a mere mass of muscle and nerve as suffering pain, is about as truthful and rational as to say that it is cruel to cut down a tree, though a silly, ignorant looker-on might shriek when the leg moved, for about the same cause and with the same reason that the African grovels before his fetich.

Did the reader ever see a rabbit completely under the influence of chloral? Lying prostrate, with flaccid limbs, with head sunk back on the limp neck, motionless and still, at first sight, it seems quite dead and gone. But a gentle heaving of the body, a rise and a fall every few seconds, tells you that it still breathes; and a finger placed on the chest may feel the quick throb of the still beating heart. You pull it and pinch it; it does not move. You prick with a needle the exquisitely-sensitive cornea of its eye; it makes no sign, save only perhaps a wink. You make a great cut through its skin with a sharp knife; it does not wince. You handle, and divide, and pinch nerves which, in ourselves, are full of feeling; it gives no sign of pain. Yet it is full of action. To the physiologist, its body, though poor in what the vulgar call life, is still the stage of manifold events, and each event a problem, with a crowd of still harder problems at its back. He therefore brings to bear on this breathing, pulsating, but otherwise quiescent frame, the instruments which are the tools of his research. He takes deft tracings of the ebb and flow of blood in the widening and narrowing vessels; he measures the time and the force

of each throb of the heart, while by light galvanic touches he stirs this part or quiets that; he takes note of the rise and fall of the chest-walls, as they quicken or grow slow, as they wax or wane, under this influence or that; he gathers the juice which pours from one or another gland; he divides this nerve, he stimulates that, and marks the result of each; he brings subtile poisons to bear on the whole frame, or on parts; and, having done what he wished to do, having obtained, in the shape of careful notes or delicate tracings, answers to the questions he wished to put, he finishes a painless death by the removal of all the blood from the body, or by any other means that best suit him at the time. I am not exaggerating when I say that this is at the present day one of the commonest forms of vivisectional experiment; this is what newspaper writers speak of as "torture," and, on the strength of it, accuse cultivated physiologists of barbaric cruelty.

A dog under chloroform or morphia may be brought to very nearly the same condition as a rabbit under chloral; but, as far as my experience goes, the same long duration of complete quiescence is maintained with greater difficulty. Dogs sometimes howl under chloroform or morphia when nothing is being done to them, and under circumstances in which they can be suffering no pain. At the moment when the chloroform begins to take effect upon them, when probably confused carnivorous visions chase through their brains, the howling is often excessive. Any one who knows any thing about the administration of chloroform to human beings, is well aware how frequent cries and noises are in the stage of excitement, and how little dependence can be placed on them as signs of pain.

In a large number of cases, then, where anæsthetics of one kind or another are used, vivisectional experiments cause no pain at all; and, as far as I know, in this country, at least, physiologists always use anæsthetics where they can. They do so not only for the sake of the animal, but also for the sake of the experiment itself. Unless they are studying actual manifestations of feeling, pain, with all its consequences, is a disturbing element which must by all possible means be eliminated, if the experiment is to have its due value. The apparent lifelessness of the animal is the physiologist's opportunity; struggling limbs would utterly defeat his aims, and a sudden start might wreck his whole experiment. Chloroform and other anæsthetics have immensely lessened human suffering, not only by simply diminishing pain, but even still more by putting it in the power of the surgeon to perform operations which he otherwise would not dare to attempt. In the same way they have powerfully aided the progress of physiology, by rendering possible new experiments, and by allowing the investigator to analyze securely phenomena which otherwise would, perhaps forever, have remained confused through the disturbances caused by pain.

There are some experiments, however, requiring vivisection, in

which the use of chloral or other anæsthetics is, for various reasons, inadmissible or undesirable. These form two classes. In the first and most numerous, the experiment is generally a short one, and quickly carried out, and the pain slight and transient. It is, of course, impossible for any one to judge truly of the pain felt by any other body, and we may err in two ways in estimating the pain felt by animals. We may over-estimate or under-estimate it. Perhaps a rough but tolerably safe test of great pain or distress may be gained by noting whether the animal is willing to eat or not. When a rabbit, for instance, not previously starved, begins to munch carrots immediately after an operation, or even continues to munch during the greater part of the time the operation is being performed, it is only fair to conclude that the operation cannot be very painful. I may add that, in the experience of experimental physiologists, the skin of the dog and the rabbit—allowance being made for individual peculiarities—is not nearly so sensitive as the human skin.

The second class of experiments carried on without anæsthetics—those entailing a considerable amount of pain—are not only by far the least numerous, *but must of necessity become less and less numerous as physiology advances.* The end which the physiologist has in view is to analyze the life of any being into its constituent factors. As his science advances, he becomes more and more able to disengage any one of these factors from the rest, and so to study it by itself. He can already, as we have seen, study the complicated phenomena of the circulation of the blood, of respiration, of various kinds of movement, quite apart from and independent of the presence of consciousness. As his knowledge widens and his means of research multiply, this power of analysis will grow more and more; and by-and-by, if physiology be allowed free scope for its development, there will come a day when the physiologist, in his experimental inquiries, will cause pain then, and then only, when pain is the actual object of his study. And that he will probably study best upon himself.

At the present day, the greatest amount of pain to animals is probably caused in experiments which perhaps hardly come under the title of vivisection—experiments in which the effects of starvation or of insufficient food, or the actions of poisons, are being studied. These, however, lead to valuable results. The pain which is the greatest in amount, and the least worthy in object, is the pain which comes to animals whose bodies have been used as tests to ascertain the poisonous nature of some suspected material; but this is a matter of the witness-box, not of physiology.

We may conclude, then, that physiologists are the cause to animals of much death, of a good deal of slight pain, and of some amount of severe pain. A very active physiologist will, for instance, in a year, be the means of bringing about, for the sake of science, as much death as a small village will, in a week, for the sake of its mouths and its

fun, and will give rise to about as much pain as a not too enthusiastic sportsman in a short sporting-season.

We have now to ask: What justification does he plead for this death and this pain? What good to mankind is thereby wrought which could not otherwise be gained?

His answer is, that the science of physiology is thereby advanced; that our knowledge of the laws of life has, in the main, been won by experiments on living animals. He, of course, cannot, and no one can, tell the "might have been." Without any such experiments, physics and chemistry, aided by mathematics, might have synthetically resolved the problems of life (though even then it might be said that both physics and chemistry sprang from the older biologic lore, and not so long ago a common physiological preparation, the muscle and nerve of a frog, started a new epoch in physics); but, as a matter of history, experiments on living animals have been the stepping-stones of phyiological progress.

The great Vesalius, the founder of modern anatomy, turning his thoughts to the uses of the structures he had so well described, saw clearly that the problems opening up before him could be settled only by vivisection. In his great work, "De Corporis Humani Fabrica," may be read the evidence, not only that he performed experiments on living animals, but that, had he not in so inscrutable a way forsaken the arduous pleasures of learning for the gossip of a court, those experiments would have led him up to and probably beyond the discovery which years afterward marked an epoch in physiology, and made the name of Harvey immortal. He, indeed, sowed the seed whose fruit Harvey reaped. The corner-stone of physiology, the doctrine of the circulation of the blood, was not built up without death and pain to animals. To-day, it is true, much of the evidence touching the flow of blood may be shown on a dead body, yet the full proof cannot be given even now without an experiment on a living creature; and certainly Harvey's thoughts were guided by his study of the living, palpitating heart, and the motions of the living arteries, quite as much as by the suggestions coming from dead valves and veins.

After Harvey came Haller, whose keen intellect dispersed the misty notions of the spiritualists, and by the establishment of the doctrine of "irritability" laid the foundations of the true physiology of the nervous system: he too, in his work, wrought death and suffering on animals.

Another great step onward was made when Charles Bell and Magendie, by experiments on animals more painful than any of the present day, traced out the distinction between motor and sensory nerves; and yet another, when Marshall Hall and others demonstrated by vivisections the wide-spread occurrence and vast importance of reflex actions.

What was begun with death and pain has been carried forward by the same means. I assert deliberately that all our real knowledge of

the physiology of the nervous system—compared with which all the rest of physiology, judged either from a practical or from a theoretical point of view, is a mere appendage—has been gained by experiment, that its fundamental truths have come to us through inquiries entailing more or less vivisection. By meditating over the differences in structure visible in the nervous systems of different animals, a shrewd observer might guess at the use of some particular part; but till verified by experiment, the guess would remain a guess; and experiment shows that such guesses may be entirely wrong. Where experiment has given a clew, careful observations have frequently thrown light on physiological problems. Without the experimental clew, the phenomena would ever have remained a hopeless puzzle, or have served to bolster up some baseless fancy. What disease, or what structure in what animal, could ever have made us acquainted with that "inhibitory" function of the pneumogastric nerve which the vivisectional experiment of Weber first detected? What a light that one experiment has thrown on the working of the nervous system! What disease could have told us that which we have learned from the experiments of Du Bois-Reymond and of Pflüger? Where would physiological science be now if the labors of Flourens, Brown-Séquard, Schiff, Vulpian, Goltz, Waller, and others, were suddenly wiped away from the records of the past? Yet each of these names recalls long series of experiments, some of them painful in character, on living animals.

I repeat, take away from the physiology of the nervous system the backbone of experimental knowledge, and it would fall into a shapeless, huddled mass.

The chemistry of living beings, one would imagine at first thoughts, might be investigated without distressing the organisms which formed the subjects of research. The labors of Lavoisier and Priestley, who first made clear the chemistry of respiration, if they entailed no use of the knife, caused at times a no less painful suffocation; while the great advances which have been made in this branch of the study during the last quarter of a century, and are still being made, necessitate almost daily vivisection, in order that the gases of the blood may be studied in exactly the same condition as they are in the living body. Even still more bloody has been the path by following which we have gained the knowledge we now possess of the chemistry of digestion and nutrition. I have only to mention the names of Bidder, and Schmidt, and Bernard, to call to the mind of the physiological student important results, nearly all reached through vivisection. The shifts and changes of the elements within our body are too subtile and complex to be divined from the results of the chemical laboratory; the physiologist has to search for them within the body, and to mark the compounds changing in the very spot where they change; otherwise all is guess-work.

Among the labors of the present generation, none perhaps have already more far-reaching results, none hold out more promise of fruit in the future, than those which bear on the influence of the nervous system over the circulation of the blood and over nutrition. The knowledge we are gradually acquiring of the subtile nervous bonds which bind together the unconscious members of the animal commonwealth, which make each part or organ at once the slave and guardian of every other, and which with cords of nervous sympathy draw each moiety of the body to work for the good of all, is putting a new aspect on physiology, and throwing many a gleam of light into the very darkest regions of the science. The words "inflammation" and "fever," bandied about of old as mystery-words, sounding much but signifying little—shuttlecocks tossed to and fro from one school of *doctrinaire* pathologists to another—now at last, through the labors of modern physiology, seem in a fair way of being understood. That understanding, when it is complete, will have been gained step by step through experiments on living animals, one of the first of which was Claude Bernard's research on vaso-motor nerves.[1]

There still remains the question, What good does physiology bring to mankind? Of the value of physiology as a not insignificant segment of the circle of universal knowledge, nothing need be said; where saying aught is necessary, it would be useless. Nor need much be said concerning the practical value of physiology as a basis for the conduct of life. So long as men refuse to learn or to listen to physiology in order that they may the better use their bodies, it would be hopeless and useless to talk of the day when they may come to it for instruction how to form their minds and mould their natures. It will be enough for my present purpose to point out briefly the relations of physiology to the practical art of medicine.

These are twofold. In the first place, the medical profession is largely indebted to physiology on account of special discoveries and particular experimental researches. If we regard the profession simply as a body of men who possess or should possess a remedy for every disease, this may seem an exaggerated statement. Many of the remedies in use or in vogue at the present day have been discovered by chance, borrowed from ignorant savages, or lighted on by blind trials. Physiology can lay no claim to the introduction of opium or quinine. Where specific remedies have been suggested by physiologi-

[1] The great importance of the vaso-motor system justly led Mr. Huxley to introduce into his "Elementary Lessons in Physiology" Bernard's fundamental experiment with some such words as "a rabbit may be made to blush artificially by dividing the sympathetic nerve." A writer, apparently biased by the memories of his own boyhood, has accused Mr. Huxley of thereby dangerously inciting boys and girls to cruelty, as if the division of the sympathetic nerve were the sort of thing a school-boy might do with a pocket-knife and a bit of string. Is it any use to enlighten the malevolent ignorance of such minds by telling them that many physiological experiments require such skill and care as make ordinary surgical operations seem rough and easy proceedings?

cal results or theories, it has not seldom happened that the remedies, though useful, have been given for a wrong reason, or have done good in a way which was not expected.

But if we look upon the medical profession as a body of men, cunning to detect the nature and to forecast the issues of the bodily ills under which we suffer, skillful in the use of means to avoid or to lessen those ills, rich in resources whereby pain is diminished and dangerous maladies artfully guided to a happy end, then we owe physiology many and great debts. Did the reader ever suffer, or witness others suffer, with subsequent relief, a severe surgical operation? If so, let him revere the name of John Hunter, the father of modern surgery. But Hunter was emphatically a physiologist; his surgery was but the carrying into practice of physiological ideas, many of which were got by experiments on living animals. Does the reader know that in all great surgical operations there are moments of imminent danger lest life steal away in gushes of blood from the divided vessels, danger now securely met by ligatures scientifically and deftly tied? Does he know that there was a time when the danger was imperfectly met by hot searing-irons and other rude means, and that the introduction of ligatures, with their proper application, is due to experiments, cruel experiments, if you like, on dogs and other dumb animals, experiments eminently physiological in their nature, about which much may be read in the book of "Jones on Hæmorrhage?" Even now, year by year, the scientific surgeon, by experiments on animals, is at once adding to physiological knowledge and bettering his treatment of wounded or diseased arteries. Has the reader seen any one once stricken by paralysis, or bowed down by some nervous malady, yet afterward made whole and brought back to fair, if not vigorous, health? The advice which turned such a one toward recovery was based on knowledge originally drawn from the vivisectional experiments of physiologists, and made safe by matured experience. Or has he watched any dear friend fading away in that terrible malady diabetes, after rejoicing that for a season he seemed to be gathering strength and ceasing to fail, even if not regaining health? The only gleam of light into that mysterious disease which we possess, came from the vivisectional researches of Claude Bernard on the formation of glycogen in the liver; and by judiciously acting upon the results of those researches the skillful physician can sometimes stay its ravages. He cannot cure it even now; and unless some empiric remedy be found by chance, will never cure it, until, by the death of many animals in the physiological laboratory, the mystery of the glycogenic function of the liver be cleared up.

But why need I go on adding one special benefit to another? They may all be summed up in one sentence, which embodies the whole relation of physiology to the medical profession.

The art of medicine is the science of physiology applied to detailed

vital phenomena by the help of a wisdom which comes of enlightened experience, and an ingenuity which is born of practice. Were there not a single case on record in which physiology had given special and direct help to the cure of the sick, there would still remain the great truth that the ideas of physiology are the mother-ideas of medicine. The physiologist, unincumbered by the care of the sick, not weighted by the burden of desiring some immediate practical result, is the pioneer into the dark places of vital actions. The truths which he discovers in his laboratory pass over at once to the practitioner, busy in a constant struggle with the puzzling complexity of corporeal events: in his hands they are sifted, extended, and multiplied. The property of the physiologist alone, they might perhaps lie barren; used by the physician or surgeon, they soon bear fruit. The hint given by a physiologist of the past generation becomes a household word with the doctors of the present, and their records in turn offer rich stores of suggestive and corrective facts for the physiologists of the generation to come. Take away from the practical art of medicine the theoretical truths of physiology, and you would have left a crowd of busy idlers in full strife over fantastic ideas. The reader has laughed with Molière over the follies of the *doctrinaire* physicians of times gone by. He has to thank experimental physiology that he has not the same follies to laugh over and to suffer from now. The so-called practical man is ever prone to entangle himself in and guide his conduct by baseless speculations. Such has been the case with medicine. The history of medicine in past centuries is largely occupied with the conflicts of contending schools of pathology—schools which arose from this or that master putting forward a fancy, or a fragment of truth, as the basis of all medical judgment. These have given place in the present century to a rational pathology, which knows no school and swears to the words of no master, but is slowly and surely unraveling, bit by bit, the many separate tangled knots of disease. They have given place because men have come to see that maladies can only be mastered through a scientific comprehension of the nature of disease; that pathology, the science of disease, being a part of, is inseparable from, physiology, the science of life; that the methods of both are the same, for in each a sagacious observation starts an inquiry, which a well-directed series of experiments brings to a successful end.

Many, if not most, of these experiments must be made on living beings. Hence it is that animals are killed and suffer pain, in order that physiological knowledge may be increased, and disease made less.

Take away from the art of medicine all that with which physiology has enriched it, and the surgeon or the physician of to-day would be little better than a mystery-man, or a quack vender of chance-gotten drugs. Take out of the present system of physiology all that has been gained by experiments on living animals, and the whole structure

would collapse, leaving nothing but a few isolated facts of human experience.

As far as we can see, what has been will be. The physiology of the future, if not hampered by any ignorant restraint, will, out of the death of animals, continue to press further and further into the mystery of—and year by year bring the physician, and not the physician only, but every one, power to prolong, to strengthen, and to purify—the life of man. By no other way can man hope to gain this end. He is thereby justified for the death he causes and the pain he gives.

We have yet to consider this question in its other aspect; we have to examine not only the effects of vivisection as far as animals are concerned, but also its influence on man himself. Little, however, need be said. Necessary vivisection, we have shown, cannot be called cruel. The question of the necessity of any particular case can only be judged by the investigator himself. I content myself with asserting that any attempt to draw up, for the guidance of others, a general definition of necessary and unnecessary vivisection, must prove utterly futile. Only he who is making an inquiry knows his own needs. If he experiments recklessly and needlessly, he becomes cruel, and, being cruel, will thereby be the worse. But, if he experiments carefully and heedfully, never causing pain where it could be avoided, never sacrificing a life without having in view some object, to attain which there seemed no other way, remembering that whoever "tortures" either dead or living nature carelessly will get no true response, there is no reason why his moral nature should suffer even ever so little tarnish. On the contrary, experience teaches us that earnest physiologists, who have killed animals in the single hope of gaining new truths or of making old ones plain, have grown more gentle and more careful the longer they worked and the more experiments they made.

The effects of vivisection on the moral nature of man may fairly be tested by experience. There are in this country several physiologists —myself among the number—who have for several years performed experiments on living animals. We have done repeatedly the things which a distinguished lady has seen fit to say "are best spoken of as nameless." I can confidently appeal to all who know us, whether they have seen any deterioration in our moral nature, as the result of our work; whether we are to-day less careful of giving pain than we were when we began to experiment; whether they can trace in us any lessening of that sympathy with dumb animals, which all men should feel even in the very thickest of the struggle for existence.—*Macmillan's Magazine.*

A FEATHER.

By W. K. BROOKS,
OF THE AGASSIZ MUSEUM.

ALTHOUGH not by a balloon, yet the Atlantic has been crossed in the air, and "what has been can be." There are enough well-authenticated cases of the occurrence of American wild birds on the west coast of Europe to prove that the trip can be made by birds, and it is probable that successful navigation of the air will be the fruit of careful study of that natural flying-machine, a bird's wing.

Every person who has not given more than a passing thought to the mechanism of flight is confident that he understands the whole subject, and tells you, if you ask, that the bird rows through the air with its wings, and that our lack of available force and of a sufficiently strong and light material is the only difficulty in the way of a successful flying-machine.

A very little study of a bird's wing and its action will show that it is not by any means simple, and that every part and every curve and angle has a use, and helps in the performance of the function of the whole, which function is not yet perfectly understood, but does not in the least resemble the action of a paddle or oar. We shall also learn that all attempts to construct flying-machines have been made with an utter disregard of every thing that a wing might have taught. To this sweeping assertion I know of only two exceptions; a boy's kite, and the little circle of card-board which runs up the kite-string in such a mysterious way, bear a very slight resemblance to a wing, in their mode of action, and may contain the germ of a successful flying-machine.

To point out some of the facts already known about flying is one of the objects of this paper; another is to show how much there is to be learned about any natural object, and the way to set about it; for he who knows all that is to be learned *about* a wing has a good store of useful information, but he who knows all that may be learned *from* a wing is a wise man.

Let us examine a feather. When I say "examine a feather," I mean, let "every one take the trouble to pull a quill-feather from an old duster, or find an old quill-pen, or in some way get possession of an actual feather, to see for himself what I wish to show; for, if what I have to say is not worth this trouble, it is not worth reading at all.

Having found your feather, notice, first, the great strength of the shaft, compared with its lightness, and how secured by placing almost all the material on the outer wall of the quill. Notice, too, that the quill, where strength is most necessary, is tubular, while the rest of the shaft has a groove on its lower surface, and tapers toward the tip,

so that it may be bent downward very easily by pressure near the tip, but does not bend so easily the other way. Notice, too, that the shaft is not straight, but bent so that the upper surface of the feather is convex, and the lower concave. We shall soon find a meaning in all these properties.

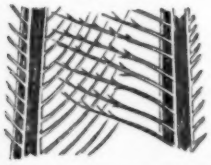
Passing now from the shaft to the vane, we see that the two sides are not alike: one edge, or vane—the one on the right-hand side of every feather in the right wing, that is, the side nearest the tip of the spread wing—is short and stiff, while the vane on the other side of the shaft is broad and flexible; and, by examining the feathers in their places in the wing, we see that the broad inside edge of the first or outside feather passes under the stiff, narrow outside edge of the next feather, which has its own inner edge supported in the same way by the third feather, and so on through the wing. When the wing is flapped downward through the air, the broad edge of each feather is pressed against the inflexible narrow edge of the feather next it, and the whole wing is thus made air-tight; but, when the wing is moved the other way, the broad edges have nothing to support them, and are pressed downward, so that the air can pass between the feathers.

The vane is also made up of separate pieces. If it is carefully examined, separate pieces, or "barbs," will be seen running off from each side of the shaft at a slight angle, and parallel to each other, united in such a way as to form two flat plates, the vanes. These barbs are fastened to each other quite firmly, but, if part of the vane is pulled down toward the quill, the barbs will separate at last with a tearing sound, and if this is repeated in a few places it will give the feather a very draggled appearance, and it will seem torn beyond possibility of restoration; but, if it be drawn gently between the fingers two or three times from base to tip, the broken places will unite so perfectly that it may be quite impossible to find them again. The working of the mechanism by which the attachment is made is so perfect that it need only be noticed to be admired, and careful examination will reveal the simple means by which it is accomplished.

Each barb, when examined with a lens, is seen to bear some resemblance to the whole feather; like the feather, it has a shaft running longitudinally, and a vane on each side of it. These vanes are unequal, as in the whole feather, and they are composed of separate pieces running off from the shaft, and called "barblets," because they are to the barb what the barbs are to the whole feather. On the side of the barb toward the tip of the feather the barblets run out from the shaft of the barb nearly at right angles, and send off from their lower surfaces little hooks at regular intervals, all pointing downward; on the other side of the barb the barblets have no hooks, and, instead of being set at a large angle with the shaft, they are almost parallel with it, so that where they meet and run under the hooked

barblets from the other side of the next barb they cross at right angles, and each hook falls directly over one of the straight barblets and fastens to it.

Fig. 1.



Part of Two Barbs from Feather of Bird-of-Paradise, showing Barblets and the Hooks which fasten them (magnified).—(From *Hardwick's Science Gossip.*)

Fig. 2.

Barbs, Barblets, and Hooks, from Feather of Goose (magnified).

This is a very beautiful adaptation, but what is the use of it? Why could not the whole vane be made in one piece? It is commonly said that its purpose is the same as that accomplished by the overlapping of the feathers, to form valves which shall allow the air to pass in one direction but to resist its passage in the other. Unfortunately, the hooks are arranged in just the wrong way for this, for pressure from above tightens them, while pressure from below tends to loosen them, although they are too firmly fastened to be easily unfastened. The true use of the separate pieces seems to be to secure that all-important property, the greatest strength, by the least use of material; and it is done in precisely the way that men have employed for securing the same end.

A scantling of wood placed on its edge will support a much greater weight than one placed on its side; so, in laying a floor, instead of laying all the boards on their sides, which would not be strong enough, or placing them all on their edges, which would use too much wood, the plan is to place on edge a sufficient number, and on these to lay the floor of boards on their sides.

The method employed in the feather is still better than this: the shaft of each barb is flattened vertically, but, instead of a separate floor laid on these, the top of each rafter, or barb, is split, and these split portions are bent down and bound to each other by the hooks already spoken of, arching over the spaces between the barbs, in exactly the way that the arches of masonry span the spaces between the iron girders of a fire-proof floor.

Before we shall be prepared to understand the way the feathers act in flight, we must examine the way in which they are placed in the wing. The anterior edge of the wing is a firm rim of bone, and the quills are fastened to this rim, with the flexible end of each feather projecting backward with nothing but adjacent feathers to support it, so that the posterior border of the wing bends very easily. The feathers are of such a shape that the wing is convex on its upper surface, and concave below.

When the wing is moved downward through the air, the feathers are pressed together; the air is confined in the concave surface of the wing, and the bird is raised up; but, when the wing is moved up to repeat the stroke, the air rushes down between the feathers. This is the paddling motion popularly supposed to be flight, but really only a small part of it. The air, being gaseous, does not remain passive under the descending wing, but tends to slide out, and as the front is unyielding, while the back is flexible, the air finds this exit, bending up the tips of the feathers, and sliding out backward and upward, while the feathers, and with them the bird, slide forward and downward. The bird can rotate its wings as well as flap them, and, by fixing them at such an angle that the fall occasioned by sliding shall just balance the lift given by the downward flap, it is able to move forward without rising or falling, although the motion of its wings is up and down; and, by changing the inclination of the wings a little, it can go up or down at the same time that it moves forward.

This is only an outline of what is known of the mechanism of flight—and many parts of the process are not yet understood—but we know enough to be able to appreciate the wonderful way in which every part, and every curve and outline, is adapted to its use; and the attention of thoughtful men has long been attracted by these and the countless similar adaptations in Nature, and many of the greatest thinkers have occupied themselves in attempts to understand the way in which they have been produced. Some have decided that adaptation implies design; and hence these adaptations must be the direct work of a personal designer and creator; but adaptation alone does not always imply design. I may go into the woods and find a young tree adapted for a cane, but no one will say that it was designed for a cane; and I once knew a very unskillful amateur carpenter, who was asked, at the close of a very industrious day's work, what he had made. He answered, "Well, I designed it to be a rustic chair, but I think it will answer nicely as a saw-buck." In this case the adaptation was certainly not the fruit of design.

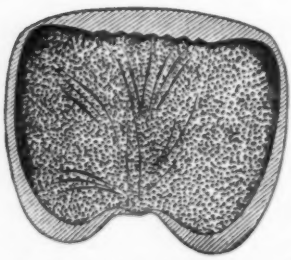
But, even if design can be shown, it does not follow that the adaptation is the fruit of direct creative interposition; and the fact that it is not always perfect—that, perfect as the wing is in most birds, more than one species has become extinct in recent times, on account of the rudimentary and useless state of the wings—has been held by many to be sufficient proof that the adaptation was not produced in this way.

We shall be able to take a more fair view of this question after we have examined the ultimate nature—the homology, as it is called—of the organs of flight.

Feathers evidently take the place occupied by hair in mammals; and, in some birds which do not fly—such as the ostrich—they are very like hair; and examination of the microscopic structure and mode of growth of a feather shows that it is formed in the same way

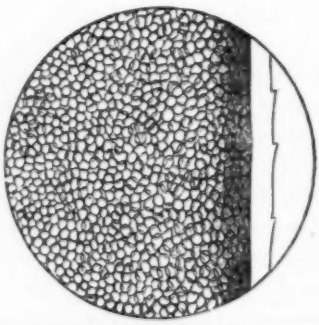
with hair, claws, or finger-nails, and is only modified skin. When a section through a piece of skin is examined with the aid of a moderately-powerful microscope, the lower or internal surface is seen to be made up of little, irregularly-rounded cells, or bags, with soft semi-fluid contents; and, while the animal is alive, new cells are constantly forming under the old ones, which are pushed outward and crowded together, and gradually lose their soft contents, and are flattened out into very small scales. The outer layer of the skin is made up of

FIG. 3.



TRANSVERSE SECTION OF SHAFT OF PRIMARY WING-FEATHER OF A GOOSE, magnified to show the cellular structure.

FIG. 4.



LONGITUDINAL SECTION OF SAME, more magnified.

these scales, which are fastened to each other firmly enough to be separated from the living layer below in a thin sheet, as happens when a blister is raised on the hand by unusual work, but in most parts of the body they are slowly rubbed off as new ones grow; but at the tips of the fingers they are so firmly united that they form horny plates, or "nails," which are pushed forward as new cells form at the root.

In the skin of a bird where a new feather is to grow there is a little pit, and, at the bottom of this, an elevation or pyramid; extending up one side of this pyramid is a groove, or furrow, deepest at the base, and gradually growing shallower until it disappears near the top; from each side of this furrow a great many smaller grooves extend around to the other side of the pyramid, and these also decrease in depth, and at last disappear just as they are about to meet on the side opposite the large furrow. The whole pyramid is covered with skin, and the surface is made of the same scales, or flattened cells, that are found over the rest of the surface of the body; but, instead of falling off when they are pushed out by the new ones below them, they become united or welded to each other, so as to form a horny coat over the surface of the pyramid, with ridges on its lower or inner surface, corresponding to the grooves on the pyramid; and, as new cells grow at the base, this coat or cast of the surface is pushed upward till it breaks at its thinnest part, which is, of course, the smooth part without ridges opposite the large furrow; and then, as it is

pushed outward and flattened, it assumes the form of a feather, the ridge formed in the main furrow being the shaft, while the casts of the side grooves form the separate barbs of the vane. When all of the vane has been formed and pushed forward, the pyramid loses its grooves and becomes smooth, and the wall now formed on its surface, being of the same thickness in all parts, does not break, but remains tubular and forms the quill, which is attached to what is left of the pyramid. A finger-nail or a hair is formed from the same kind of scales in the same way, the process differing only in those features which give to each organ its special character. Feathers, scales, hair, claws, and nails, all are made alike from the dead, flattened cells crowded to the surface by the process of growth.

If, passing from the feather to the wing, we study that in the same way, we shall find that it is made, part for part, on the same plan as the arm of a man, the fore-leg of a horse, the fore-foot of a turtle or frog, and the fin of a fish; and, when these organs are compared in their earlier stages of growth, the resemblance is very perfect; and it is only as one becomes fitted for swimming, another for flying, another for running, and another for handling and feeling, that the differences between them begin to appear. Studying now the whole body of the bird in the same way, and comparing it with a mammal, as the horse; a reptile, as the turtle; a batrachian, as the frog and a fish—we find that all these animals are constructed on the same general plan, and here, also, the resemblance is stronger in the earlier life of the animals. We find, however, that they do not all resemble each other in the same degree, for the bird is more like the turtle than like any of the others, and, when full grown, it preserves some resemblance to reptiles; and there is an animal, found only in the fossil state, called the archiopteryx, which unites in itself many of the characteristics of birds, such as the possession of feathers, with other characteristics as unmistakably reptilian.

Such are the principal facts to be learned about the wing, and any explanation of its origin must account for them all; and the same or similar facts may be learned by studying almost any organ or animal.

To recapitulate: they are, first, the wonderful adaptation of all parts for their uses, rendered still more wonderful by the second fact, that the parts so adapted are modified forms of what are called homologous organs, that is, organs having the same plan, but adapted to quite different uses, and having very little superficial resemblance; third, the fact that, when the growth of these homologous parts is compared, it is found that in their earlier stages they are very much alike, and differ so far as and at the same time that they acquire those characteristics that fit them for their special uses; fourth, is the fact that there are or have been animals whose structure has been so little modified that they seem to connect animals of very different but homologous structure.

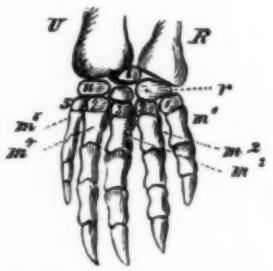
Now, what is the meaning of these relations between organs and between animals? For that they have a meaning must be clear to all, and it is fair to presume that it is one that can be discovered by investigation.

The fact that two or many different animals are constructed on the same plan seems to indicate some kind of connection between the animals themselves, and it is the work of the zoologist to find what it is that thus connects them.

FIG. 5.

FORE-FOOT, OR "WING," OF EMBRYO YELLOW WARBLER.—(From Morse.) The hand in a Reptile and Embryo Bird compared. *U*, ulna; *R*, radius; *u*, ulnare, or cuneiform bone; *r*, radiale, or scaphoid bone; *c*, centrale. 1, 2, 3, 4, 5, first, second, third, fourth, and fifth carpals, m^1, m^2, m^3, m^4, m^5, corresponding metacarpals.

FIG. 6.



FORE-FOOT, OR "PADDLE," OF SNAPPING-TURTLE.—(From Gegenbauer.)

Two theories have been proposed, each of which seems to meet most of the points to be explained, but each seems to fail in some respects. One of these is, that the connection between different groups of animals is to be found only in the mind of their Creator; the other is, that there is a direct genetic connection or relationship between them.

Each of these theories is conceivable and worthy of consideration, for we can find examples of the building up of systems somewhat resembling the animal kingdom in each of these ways. The various kinds of steam-engines, for instance, are adapted each to its special work, with an accuracy rivaling that of Nature, yet all of them can be shown to be constructed on substantially the same plan.

If we trace the history of any form, such as the steep-grade locomotive, we find, as we go backward, that it loses, one by one, all of its special adaptations, until at last it is only a common locomotive at up-hill work. Tracing the history of the locomotive in the same way, we find that its special adaptations disappear, until it is nothing

but a power-engine placed on wheels—not the improved power-engine of the present day, but an unimproved and rudimentary form. We might trace the history of other forms in the same way, until we had found the one source for them all.

In this case there can be no genetic connection; each engine is an independent thing, and the only connection is an ideal one in the minds of the inventors; that is, the idea of the steam-engine has gone through a process of evolution, expansion, and perfection, and most of the steps in the process have been embodied in real engines, so that together they form a manifestation or record of the changes that the idea has undergone.

According to the theory of which Agassiz is the most celebrated advocate, the phenomena of life are to be explained in a somewhat similar way. Recognizing all the facts which seem to indicate the evolution of the animal kingdom, and being himself the discoverer of very many of them, he says that the evolution is simply the evolution of an idea in the mind of the Creator, which idea has been embodied in material form in such a way that it can be traced by the study of the animals that form its expression.

The other theory may also be illustrated by an example: When we compare languages which philologists tell us have descended from one parent tongue, we are attracted by their differences only, and it needs careful study and comparison to understand the similarity of plan which underlies them all; but when their history is traced it is seen that they were originally the same, and have become different as the races using them have become more widely separated, and, coming under new and widely different physical conditions, have diverged in their habits, feelings, thoughts, and associations, and have required different forms of speech to supply their need. Here, unlike the case of the steam-engines, the language has been the same all the time, and, although men have been the means by which the change has been effected, they have not been the intelligent cause, but have been unconsciously acted upon by agencies around them.

According to the theory with which Darwin is identified, although he is not by any means the author, but has simply removed some of the most serious objections, all the different forms of life have been evolved from one source in substantially the same way that languages have originated; as animals become exposed to new conditions, new varieties adapted to these conditions arise, and, as animals thus grow different, the parent unimproved forms are unable to struggle with their more perfect descendants and become extinct, so that the animals which would connect dissimilar forms are no longer in existence.

The evidence necessary for the perfect establishment of either of these theories does not seem to have been obtained as yet, and we can only decide provisionally, according to probabilities; but the discus-

sion of the evidence already collected, or even a bare outline of it, would lead us far beyond the limits of this article, which is simply designed to show how much food for study even a feather will supply, and what broad questions it will lead us into.

WHAT THE CHEMISTRY OF THE ROCKS TEACHES.

By C. C. MERRIMAN.

IT is a general rule that substances can crystallize only while solidifying from the liquid state of either fusion or solution. The only exceptions are, that some few substances crystallize directly from their vapors without passing through the intermediate liquid form. Now, the older unstratified rocks of the geological formations, as the granites, are unquestionably fusible, are crystalline in their structure, and are practically insoluble. Therefore the evidence is conclusive that they were all at one time in a molten, fluid state.

Thus far, it would appear, geologists are agreed, since they have named these formations the igneous rocks. But, whether the melted minerals were ever heated to a higher degree than fusion—that is, to the condition of vaporized elements—is an inquiry either carefully avoided by the authorities in geology, or merely mentioned as pertaining to an ingenious hypothesis which, it is claimed, is unsustained by any sufficient proof. It remains to be seen, however, if this theory of the original gaseous form of the material elements does not follow as a necessary consequence from the chemical constitution of the rocks themselves; and if it does not explain and bear testimony in geological and cosmical sciences to such an extent as to make it absolutely essential to them.

The question here presented resolves itself into two alternatives: Either the materials of the earth's crust were formed, according to chemical laws, out of the simple elements preëxisting in liquid or gaseous form, or they were created in the condition of melted and oxidized masses ready to cool into granite and limestone. The latter supposition will hardly be seriously entertained in these days of free inquiry into the natural causes of things. It is now not only conceded, but expected, that science shall have sole jurisdiction in every case where compound bodies are the subject of investigation. To follow them back to the primal laws and elements of their being—to reveal the cause and manner of their birth among the atoms—is now the highest aim of inductive research. On this border-line of inquiry, where the known shades off into the unknown, and the finite into the infinite, science has of late gained its most signal triumphs. And it scarcely requires a prophetic sense to discern that the groundwork of

all systems of scientific knowledge will soon be laid in molecular physics.

In the constituents of the solid earth we have forms and conditions of matter of remarkable composition and complexity. The original materials of the ground, of the rocks, and of the mines, are found to be, in every case, fully saturated chemical compounds. Many of them, as the silicates, are adamantine acids neutralized by alkaline bases harder than the flint. They could not be made more stable, inert, and solid. They are materials that have apparently gone through stupendous changes, activities, and combustions, and at last have settled down to a rest that knows no waking. Science has no duty more legitimate or more imperative than to inquire how these rock-masses came to be where they are, and in the condition they are.

In pursuing this inquiry—since we find one of the alternatives to be inadmissible—it is necessary, therefore, to accept the other, namely, that the matter which composes the geological formations preëxisted as simple elements, either in liquid or gaseous form. Oxygen, which makes up fully one-half the weight of the solid parts of the earth, is and always was a gas in its free state. In regard to the remaining elements that enter into their composition, such as silicon, aluminum, calcium, and sodium, they could not all have existed on the earth at the same time as melted liquids; for the same heat which held one in fusion would have evaporated others. Some, therefore, must have been contained in the atmosphere as simple gaseous elements. Inasmuch as granite is the base and substratum of all the other formations, if we show that this must originally have been in a gaseous state, we show that every other material must have been at the same time in like condition.

The granitic rocks are by far the most abundant terrestrial substance that we know of. Geologists assign to them a depth of not less than thirty miles. And still below them there is the same or nearly the same chemical substance in fusion, as the fact and analysis of volcanic products sufficiently prove. The compound which is in excess in all granite rocks is silica, the oxide of the element silicon. The varieties are formed chiefly by small percentages, more or less, of the oxides, alumina, and magnesia. This silica, or quartz, as well as the other components of the igneous rocks, is what has been termed "burnt material." It is the product of a most complete and tremendous conflagration; for the oxidation of silicon is as much and as powerful a combustion as the oxidation or burning of coal. To accomplish this burning, every particle of the silicon must have been brought into contact with oxygen gas. This would have been simply impossible if the mineral element had always been in a melted mass of miles in depth; for this, if for no other reason, that the oxygen could not get at it—certainly not, if it was covered by other solid or liquid substances. Or, if it were conceded that silicon ever formed the sur-

face of the earth, then all other materials of what is now the crust must have been gases above it; and, as nine-tenths of the elements in vapor are heavier than oxygen—many of them more than ten times as heavy—this gas could never have even touched this imaginary sea of silicon. The oxidation, then, was only possible in the regions of the atmosphere where oxygen existed and abounded. There only among the free-moving gases could the incalculable amount of heat evolved in the combination be carried off.

We confidently assume, therefore, that the whole of this most abundant mineral element once existed in the atmosphere in the form of a high-heated gas; and that some time and somewhere, on the confines of the enormously-extended sphere of vapors, there was found a current sufficiently cool to condense a portion of it. If the vapor of silicon follows the general rule—that the density of gases is in proportion to their atomic weights—then it was but a fraction heavier than oxygen, and therefore not far below it in the atmospheric strata. The unceasing commotion of the elements would soon have brought this first cloud-mist of silicon into contact with oxygen, to which it has a strong affinity under high heat. Oxidized, and in molten drops of silica, or crystals of quartz, this new-formed material commenced its descent toward the centre of gravity—the first creation from the primordial elements. As it fell into the more heated regions below, it was probably soon evaporated, and, the vapor rising, carried up with it the heat taken up in the evaporation. It was again condensed, its heat given up, and it descended for another charge of the internal fires. This, in all probability, is the epitome of the process of world-cooling.

At last, the showers of melted silex reached the liquid surface of the nucleus, which the force of gravity and compression must have formed, at an early period of the nebulous globe, of less or greater extent about its centre. From this period the increasing torrents of silica, intermingled with the silicates which were forming at the same time, poured down through the heavy vapors, and filled up the furlongs-deep of granite ocean. On this vast deposit, and at about this stage of the gradual cooling of the earth, began, we must suppose, the first hardening and crusting over of the surface, since at this point, near the close of the granite age, first commences the division of the earth's crust into varieties and layers more or less distinct, as also the upbearing of the heavy metals which, without this surface-hardening, could never have floated on any molten sea of minerals. The slow cooling of the granite masses beneath this crust and under the enormous atmospheric or other superincumbent pressure, conformed them to all the acknowledged conditions of the formation of the igneous rocks.

There is found in the different beds of the granitic rocks every proportion of the admixture of silica with the silicates of alumina.

It is as if chances as variable as winds and storms had regulated the production and mixture. There is every gradation in the texture of granite, from the fine-grained blocks of the quarry to the coarse, compacted breccia so common among bowlders. It is as if the deeper beds had slowly cooled under great compression and consequent immobility of the particles, while the superficial layers had been worked up and conglomerated at the surface. There are specimens of granite composed of massive angular crystals, that seem as if they had been thrown together and cemented. It is, again, as if they were the congealed *débris* of some terrific hail-storm of quartz, mica, and feldspar.

After the greater part of the silicious minerals had been deposited, and the cooler exterior gases had thus been let down to a nearer vicinity with the heavier vapors, we find that the metals proper began gradually to condense and fall. Those which have no active affinities for the other elements were deposited in their native purity. Others took on the forms of oxides or sulphurets, according to their first exposures or strongest attractions. Among the first of these cloud-productions, the rock records tell us, were the scanty rainfalls of gold and platinum, and the more plentiful showers of silver and copper. Rivulets of native ores ran along the hardening crust, filling the veins and crevices, or mingling with the liquid quartz that was seaming the granite and gneiss.

Then from clouds of condensing iron vapor, that must have burned and scintillated with indescribable magnificence, fell the thick heavy storms of the black lodestone, the blood-red hematite, or the dark-yellow pyrites. Possibly storm-centres were established, over which the cyclones were held concentrated, and often repeated by force of intense magnetic attractions which have left their traces in almost every iron-mine.

Following these, at times and places, came on the great snow-storms of the waxy flakes of zinc-blende, and the pearly calamine, the red oxide or the white carbonate of lead, and the gray galena, the beautiful crystals of the tin-stone, the gray plumes of antimony, and all the tinted and varied forms of the less abundant ores and alloys. Meanwhile, through all the long ages of these metallic precipitations, there was continually falling over all the earth the white, impalpable powder of lime—the element calcium condensed into cloud-mist, and oxidized in the upper regions of the air.

These were the great chemical periods of our world; when the cooling vapors of the swollen sphere were struggling to unite and hold fast the embrace against the antagonist force of heat; when the conjoined elements were pouring down their fiery torrents, and the air was laden with the falling cinders and ashes of aërial conflagrations; when the vast workshop of Nature was forming and sorting its raw materials.

We do not, however, wish to be understood as insisting that all

these minerals and metals came down in just the form and order that we have indicated, or that they were regularly deposited, and left the orderly traces that perhaps our hasty sketch would seem to imply. There were unquestionably constant and profound commotions in the atmosphere, and the commingling of the most diverse elements. There were doubtless repeated meltings and chemical recombinations at the surface, and the rending and comminuting of the newly-formed crust by internal forces. The history of the earth's irregularities and disorders forms the greater part of geology. But what we do claim as certain is, that all the constituents of the outer shell of our globe existed at one time as elemental gases above a sea of matter that was held in condensation by superincumbent pressure; that, as the earth gradually cooled, these gases condensed somewhat in the order, inversely of their volatility, and directly of their nearness to the outer bounds of the atmosphere, and fell to the surface like rain and snow from water-clouds; that they formed chemical combinations at the instant of their condensation, or subsequently according to the power of their affinities or the elements that were present; and that, excepting the more recent displacements by mechanical forces, they now lie in the earth as they fell from the heavens.

The silica and silicates, which form the base, and by far the greater part of the earth's crust, became oxides of their several elements because oxygen was the superabundant gas in its composition. There have been worlds made up apparently without oxygen; for the meteorites, which must be regarded as sample specimens from some stranger world, however they may have been dispatched to us, are mostly composed of pure crystalline and malleable iron, which could have cooled into that condition only where there was no oxygen nor carbonic gases. If chlorine had been our superabundant gas, the silicon would perhaps quite as readily have united with it, and formed as stable a compound as with oxygen. But the product, instead of being the hardest of rocks, would have been a liquid very much resembling water, a little heavier, and nearly as volatile, as the common ethers. In this case there could have been no dry land, and no living beings that we can conceive of. Eternal clouds and storms would have covered the face of a surging boundless ocean.

Hitherto, in our accounts of terrestrial phenomena, water has played no part. It is probable that it was early formed, and in the condition of vapor or steam diffused through the upper air. In this state it bears the highest degree of heat that we can produce, without decomposition. Hydrogen is the lightest of all the gases, and unquestionably took its place on the outer limits of the atmosphere. There it was brought into contact with oxygen by the commotion of the elements, and converted into steam as fast as its lowering temperature allowed of the combination. As we might expect from the respective positions of the gases, all the hydrogen which fell to the

portion of the earth in the making up of its constituents was transformed into water-vapor. Hydrogen is found in no other combination that cannot be traced directly or indirectly to the decomposition of water.

The aqueous vapor being thus formed, and lying in the upper and cooler regions of the air, it began after a time to condense and fall toward the earth. Meeting with warmer strata as it descended, it was soon evaporated and sent up with a load of heat that was set free again by a recondensation. Then another and perhaps lower descent for another charge of heat. Thus, on the outskirts of the air, water-vapor was coöperating in the work of the heavier vapors of the interior. It was the great fire-carrier of the globe during all the time of the contraction and consolidation of the lower elements. When every thing else that was condensable had turned to dust and ashes, and fallen to the earth, at last the waters reached the parched and scorious surface, and commenced that grand series of aqueous transformations which made a new earth for the indwelling of life.

In the first place, it was necessary that the upper crust should be hydrated, precisely as lime is slaked by pouring water on it. The material which had been last deposited was in reality this same caustic lime. In its lower deposits it was gradually intermixed with the silicious compounds, until these formed the masses which are now the unstratified granitic rocks. As every one knows, the slaking of quicklime absorbs a large quantity of water, which is incorporated into the solid, and great heat is evolved with enlargement of bulk. The pure silicious rocks do not take up water in this way, being what is termed anhydrous. All the rock-materials, then, that lie above the granite must, at some time, have undergone this hydrating, reheating, and swelling process. We accordingly find that all those strata which have remained in their original position, such as the gneiss, the mica schists, the clay-slates, and the primary limestones, have the appearance of having been subjected to great heat and pressure, after having been acted upon by water and steam. In some instances they have been partially melted, in others strangely contorted, and in others partly dissolved. Under certain circumstances, hot water and steam will dissolve small portions of silica, and, if charged with carbonic-acid gas, will dissolve lime quite freely.

The rainfalls of the primeval ages must have been fully saturated with this oxide of carbon, which has played such an important part in the making up of the strata. In this form it carbonated all the limestones, carried all the building-materials to the shell and coral land-makers, and furnished the supplies for the immense magazines of the hydro-carbons. And, after all this, there was enough carbonic-acid gas left in the air for the enormous vegetation of the coal-beds. But it was necessary that the carbon of this gas should be laid away in the earth in some form, either burnt or unburnt, before air-breathing

life could come to any perfection. The solidifying of the carbonic oxide was the latest and the slowest of the atmospheric changes.

It appears that during the epoch of the hydration of the lime-rocks there occurred periods when the waters were gathered into seas, and were sufficiently cooled for the existence of marine infusoria, mollusks, and corals. Life, in some form, has ever been ready to spring into being the moment that conditions and surroundings were suitable for it. After the deposition, in those temporary oceans, of considerable thicknesses of Cambrian or Silurian strata, mixed with organic remains, some rent or upheaval has let the waters down to new beds of unslaked material, which have heated, and, as it is termed, metamorphosed those first fossiliferous deposits.

The subsequent changes which the earth's crust has undergone—aqueous, volcanic, and organic—the working up of the conglomerates and sandstones, the depositing of the deep-sea beds, the overflowing of the traps and lavas, the storing away of the carboniferous treasures, are all the story of every hand-book of geology, and pertain no more to one theory than another of the origin of the rocks. When the quarries were once made and opened, the after-work was merely mechanics and masonry.

We have heretofore assumed that the gases which originally composed the aërial envelope of the earth took up separate positions therein, according to their specific gravities. This might seem to be controverted by experiments on the diffusion of gases, in which those of very different weights, as chlorine and hydrogen, will intimately commingle, even against gravity, when brought into contact. This may be true in the narrow compass of a laboratory experiment, and yet not apply to any considerable thicknesses of the gases. Such a diffusion, of one mile in depth of chlorine, would be equal to lifting up to the hydrogen a shell of solid iron two feet thick. Whether we explain the distinguishing principle of the constitution of gases as a mutual repulsion of their molecules, or, according to a late theory, as an incessant motion and clashing of atoms, there is nothing in either to warrant the supposition of the lifting or overcoming any considerable weight in the diffusion of gases. Under the first theory, diffusion, to a limited extent, would be accounted for by the small residuum of chemical or cohesive attraction that would remain between the atoms when separated as they are in gases; and, under the last theory, by the mechanical impulsion of the molecules, through their hitting against each other. Evidently, it is a principle which operates only within narrow limits, and in the lower temperatures of the gases. The sun gives no indications of such a commingling of its gaseous elements. Spectrum analysis, when applied to its outer edges, shows first hydrogen, then the vapors of sodium and magnesium, and, lastly, those of calcium and iron. The same fact and order of position are found to exist in the more condensed layers of the sun-spots.

We have also further assumed that the elements, in their gaseous states, have specific gravities corresponding to their atomic weights. It is well known that all gases, whether simple or compound, at the same temperature and pressure, and not near to a condensing point or other change of state, contain precisely the same number of molecules in the same volume. Therefore, it necessarily results that the same measures of the different gases should have weights corresponding to the weights of the molecules of which they are composed. Thus the atom of oxygen is sixteen times as heavy as that of hydrogen; therefore a cubic foot of oxygen gas will weigh sixteen times as much as a cubic foot of hydrogen gas. This is found to be experimentally true of all the gases that can be measured and weighed. The apparent but not real exceptions are that in arsenic and phosphorus two atoms of the element unite to form one molecule of the gas, thus making it twice as heavy as it would be, according to the general rule; while, in the case of mercury and cadmium, the atom divides into two in forming their vapors. Hence we are not absolutely sure in regard to the vapor-molecule, and therefore vapor-density, of such elements as carbon, silicon, and calcium, which chemists have not been able to volatilize. But there is every probability, both from analogy and the position in which some of them are found in the photosphere of the sun, that the vapors of nearly all of them correspond strictly to their combining numbers. The following table, therefore, will show the relative positions, in the atmospheric strata, of some of the most important elements, with the weights of their atoms in hydrogen units, their vapor-densities, compared with air, and the solid specific gravities of some of them as compared with water:

GASES.	Atomic Weights. H = 1.	Sp. gr. of Gas. H = 1.	Sp. gr. of Solid. Water = 1.
Hydrogen	1	.069	....
Carbon	12	.828	2.09
Nitrogen	14	.972	....
Oxygen	16	1.105	....
Sodium	23	1.59	.98
Magnesium	24	1.66	1.74
Aluminum	27.5	1.90	2.60
Silicon	28.5	1.97	2.40
Sulphur	32	2.22	2.
Chlorine	35.5	2.44	1.33
Potassium	39	2.69	.86
Calcium	40	2.76	1.58
Iron	56	3.86	7.80
Copper	63.5	4.39	8.96
Mercury	200+2	6.97	13.60
Silver	108	7.47	10.53
Gold	196.5	13.57	19.34
Platinum	198	13.66	21.50

It will be noticed from this table that the elements were arranged in positions most suitable for their combination and deposition, both in the geological order, and in the probable order of their condensa-

tion from vapors. Oxygen and silicon, which doubtless composed more than four-fifths of the entire bulk of the gases, were separated from each other only by the elements that were needed to make up the silicates. Their compound, silica, is involatile, and even infusible by itself, under any degree of heat that we can command. The same is true of lime and the earlier-formed silicates. Therefore it is impossible to decide from their volatility which of these substances would have first condensed and reached the surface. But, as the vapor of silica, when formed, would still be of nearly the same specific gravity with silicon (2.07), and would still separate by its immense volume the oxygen from the calcium below, we may suppose that in any case silica would have to be condensed and deposited, in greater part at least, before lime, the oxide of calcium, could be formed.

Along with silica were formed and deposited the silicates of alumina—mica and feldspar; then the partially fusible silicates of magnesia, lime, and iron—hornblende, augite, and talc. There followed a numerous order of complex silicates, in which the above-named ingredients are varied by small proportions of manganese, soda, strontia, zirconia, and many other mineral bases. With, and after these, was produced the lime-deposit, the last of the minerals. The metallic vapors, which were all heavier than the mineral, were condensed and deposited chiefly during the later silicate period, and somewhat in the inverse order of their volatility, but locally and irregularly as results of great perturbations, or storms in the air.

It will further be seen, from the last column of the table, that in no respect are the materials of the earth deposited according to their specific gravities as solids or liquids. There is, in the superincumbent rock and ore masses, no order of position that would indicate in the least the floating or buoyancy of the lighter substances. Therefore, their arrangement cannot be referred to any origin from liquid conditions; and the only other theory is that of their gaseous origin.

There are many apparent anomalies in the deposition of the metallic and mineral compounds, which may require much study, and perhaps further knowledge and experiment for their explanation. Thus there is in one place a carbonate of lime—marble—and in another a sulphate of lime—gypsum. There are in certain localities sulphuret-ores of iron or copper, and in others oxide-ores; while the metals of greatest vapor-density, as mercury, lead, bismuth, and antimony, are found almost exclusively in sulphuret-ores. It will perhaps eventually be established that sulphur was combined wholly into sulphuric-acid gas, as carbon was formed entirely into carbonic-acid gas; that both were brought to the surface of the earth in solution with rain-water; and that sulphur in this form united with the metals which had failed to be oxidized upon their condensation in the air, and sulphated the quick-lime in the earth, which had not been carbonated by the carbonic solution. Then there is the exceptional production in Nature

of the chloride of sodium—common salt. Apparently in this one instance the oxide is the less stable compound.

But if, as we have endeavored to prove, there is a necessity of accounting, in accordance with this theory, for the various compounds and phenomena with which geology makes us familiar, then it is in the highest degree essential that experiment and research be prosecuted in this new field. And there must be no hesitation in accepting the conclusions to which they lead. Should the nebulous origin of one planet be thus established by internal and inductive evidence, then the nebular theory of the formation of worlds, which has heretofore been received as only a provisional hypothesis, must be accepted as having a scientific basis. If the earth has once been a self-luminous body, in all respects excepting size, like the sun of to-day, it follows from analogy that the other planets have likewise been minor suns which have become extinguished by the burning out of their materials. To an observer on any unseen world among the stars, our sun should have appeared in those times as a brilliant double, or multiple star, around which nine lesser companions have shone out for a season, and then one after the other folded themselves up in darkness.

Furthermore, the study of this subject may throw light on many cosmical problems—may tell us in earth-periods, if not in years, how old the sun is when his glowing vapors begin to condense into dark clouds; and perhaps, too, something of his future prospects as a luminary. It is remarkable that the spectrum has never shown any indications of free oxygen in the atmosphere of the sun. Is not the absence of this element further corroborated by the fact that the solar spots, which there is evidence to believe are condensing clouds of iron and calcium, do not glow with fierce burning, as they would if oxygen were present? Does not the enormous volume of the sun's uncombined hydrogen indicate that it has not found, then, the element of its strongest affinity? And is there not reason to believe that the heat and light supplies of our great luminary will last all the longer for the absence of this most extravagant fire-generator?

Again, the four outer planets of our system have specific gravities varying but little from that of water. Considering central condensation from pressure, it is probable that they are not so dense as they would be if composed of the lightest compound substance that we know of. If oxygen had been there in excess, it would long ago have burned and condensed their elements, whatever they might be, into most stable and solid forms. This gas, therefore, cannot have formed any considerable part of their constitution. Is it not, then, a probable supposition that these distant planets are composed of some non-combining and inactive elements like nitrogen, and that, undisturbed by combustions or elemental agitations, they have quietly stratified into gaseous worlds, retaining in great part their original heat? So far

as the spectroscope gives any indications of their constitution, it shows them to be composed of gases unknown in the earth.

As we have stated, the four outer planets are very nearly of the specific gravity of water; then come the innumerable asteroids, filling the place of a missing planet, and of which we know but little; then three planets that are five and a half times as dense as water; and lastly, Mercury, over eight times as dense. Does not this increasing density of the planets, from the outer to the inner, imply that they have become successively formed on the exterior of one great parent globe, and received each its portion, in the main, of denser elements, as it was later born? That this effect should appear somewhat in groups of the planets, is owing, probably, to the absence or excess of oxygen among their components.

But, if this is so, what shall we say of hydrogen, the lightest of all the gases, which seems to be most abundant the nearer to the centre of the system? To explain this notable exception, might we conjecture that hydrogen is a more recent production than the worlds themselves? It has been observed time and again to burst up from the nethermost regions of the sun with inconceivable force, as if it were the pent-up product of a volcano, and to throw up columns of its flaming gas, in one case 200,000 miles high. And these great outbursts of hydrogen are always the precursors of the dark, sunken spots in the photosphere. How came this almost imponderable ether to be imprisoned in the deep craters of the sun, if it is not a product that is constantly forming in the solar caldron?

But it is easier to ask questions than to answer them. And I will close, in the fear of having been already thought too free with the scientific imagination.

THE UNITED STATES NAVAL OBSERVATORY.

By EMMA M. CONVERSE.

THE importance of establishing a first meridian for the United States at the seat of government, in connection with a National Observatory for the purpose of systematic scientific observation, attracted the attention of Congress as early as 1810. In 1813 the report of the committee, to whom the matter had been intrusted, was read before the House by one of its prominent members. But such were the disturbed condition of the country, and the absorbing interest in its military affairs during the war with Great Britain, that the subject was not again revived till 1815, when the original memorial with the several reports, hitherto presented, and the letter of the Secretary of State, read before the House in 1813, were referred to a select committee. This committee strongly advocated in its report the erection

of a National Observatory, furnished with suitable instruments and apparatus for astronomical observation, and that the President should cause such observations to be made as would determine the longitude of the Capitol with the greatest practicable degree of exactness.

But no steps were taken at that time to carry out the resolution, and the subject was not again referred to till 1818. A third memorial was then presented, soliciting not the erection of an observatory, but simply that additional observations be made to test the accuracy of results already obtained, in order to insure a correct determination of our longitude from Greenwich. Nearly three years of tedious delay were required before the requisite resolution was passed which insured the modest commencement of what is destined to become one of the great scientific institutions of the country, and, we trust, of the civilized world.

In 1821 Mr. Lambert, the original memorialist, was appointed by the President "to make astronomical observations by lunar occultations of fixed stars, solar eclipses, or any approved method adapted to ascertain the longitude of the Capitol from Greenwich." In 1823, President Monroe submitted to Congress Mr. Lambert's final report, in which he stated that by the diligent use of such instruments for his work as the country afforded, by the employment of different methods, and by the assistance of competent persons in various sections of the United States to test the accuracy of his work, he had endeavored to fulfill his commission to the extent of his ability. He gave, as the mean result, the longitude of the Capitol 76° 55′ 30″ 54 west from Greenwich. Thus the first step in the establishment of an observatory was taken in determining the longitude of the Capitol; for, without such an institution furnished with suitable instruments and apparatus, no accurate measarements of the positions of the heavenly bodies could be made, and the computation of a nautical almanac or astronomical ephemeris would be impossible.

The next movement that was made toward the accomplishment of the object was in 1825, when President Adams, in his first message, urged upon Congress the establishment of a National University. Connected with this, he earnestly recommended the erection of an astronomical observatory, to watch the phenomena of the heavens, and to give periodical publications of observations. The matter was referred to a select committee, who presented an elaborate report in 1826, accompanied by a bill to establish an observatory in the District of Columbia. Although the location, cost of the edifice, and the expense of carrying it on, were freely discussed, no action was taken in the matter; and Mr. Adams's recommendation, though associated with the progress of the nation, and independent of party or personal interest, was allowed to lie unnoticed.

But, after years of neglect and indifference on the part of Congress, a few officers of the navy had the honor of taking the first direct ac-

tion in the creation of the institution. In 1830 the Depot of Charts and Instruments for the Navy was established in Washington. This was accomplished under the orders of the Navy Commissioners, and with the sanction of the Secretary of the Navy. Lieutenant Goldsborough, through whose influence principally the bureau was created, was intrusted with the charge of it. He collected from New York and other places the chronometers, sextants, theodolites, and other instruments and charts of the navy, and located them in a building opposite the residence of the Attorney-General, Hon. William Wirt. A transit instrument was afterward added, and the naval Depot of Charts and Instruments was in working order. One duty of the officers was the careful rating of all chronometers belonging to the navy, which was at first effected by sextant and circle observations; but afterward with a thirty-inch transit instrument. This transit was mounted within a small circular building upon a brick pier having a base twenty feet below the surface, and is noteworthy as the first astronomical instrument erected for the navy at Washington.

In 1833 Lieutenant Wilkes succeeded to the charge of the depot, and obtained permission to remove the office to Capitol Hill, where it remained until 1842. He erected here at his own expense an observatory sixteen feet square, and mounted a five-foot transit. But no regular observations were made till 1838, on the departure of the exploring expedition, the principal use made of the transit being the determinatiou of time. In 1837 Lieutenant Gilliss was left in charge of the depot, and, during the absence of the exploring expedition, and in connection with it, made invaluable observations on moon culminations, occultations, and eclipses. There was not a visible culmination of the moon, occurring when the sun was an hour above the horizon, from 1838 to 1842, nor an occultation after the 15th of June, 1839, with one exception, which he did not personally observe. He also completed an important series of magnetic and meteorological observations.

As the work took on larger proportions under such devoted leadership, and valuable and expensive instruments were added, the unsuitableness of the building, the defects of the transit-instrument, and the want of space to erect a permanent circle, became more evident. Earnest solicitations were made for an appropriation for a permanent establishment, and the subject was brought before Congress by the Secretary of the Navy in 1841. Tedious and disheartening delay occurred before Congress was roused to an appreciation of the importance of the enterprise. But, after persistent effort on the part of its supporters, at the last hour of the session of 1841–'42 a bill passed both Houses without discussion, authorizing the Navy authorities to contract for the building of a suitable institution, and that it should be located on any unappropriated land in the District of Columbia which the President deemed suitable. Thus was the future observatory officially recognized.

All obstacles to further progress being happily overcome, plans for erecting a Naval Observatory under the best available conditions were speedily made matter for diligent study. Visits were made to the Northern cities to obtain assistance, distinguished astronomers were consulted, and an accomplished architect secured to draught plans, the whole care being intrusted to Lieutenant Gilliss. The locality chosen for the observatory possesses an historic interest. The site assigned to it was known as "Reservation No. 4," on the original plan of the city. It lies on the north bank of the Potomac, in the southwestern part of the city. When General Braddock marched against Fort Duquesne in the colonial wars, his troops landed and encamped on this hill. Washington's letters show that he crossed at this point from Alexandria to join Braddock at Frederick. A large rock within the grounds of the observatory is pointed out as the spot on which these landings were made. It was here that the first President proposed to locate a national university, and at a later date it was suggested by President John Quincy Adams for the site of an observatory. The base of the observatory is the second highest eminence within the city limits, and is on a level with the floor of the Congressional Library.

In 1843 Lieutenant Gilliss reported to the Navy Department the adoption of a plan for an observatory, and also the progress of the erection of a building in accordance with the plan. In 1844 the new building was ready for occupancy, and the instruments adjusted for the commencement of active work. The central building is about fifty feet square, raised on a firm foundation, and built of brick in the most thorough manner. It is two stories and a basement high, with a parapet and balustrade of wood around the top, and is surmounted by a revolving dome resting on a circular wall. The roof is nearly flat, and so arranged as to form a level promenade for gazing observations. On the east and west sides of the building are wings, and also on the south. In 1870, an observing-room for the transit-circle was added, forming an extension of the west wing. A tower and dome, to accommodate the superb new equatorial telescope recently completed, was finished in October. The equipment of the observatory in astronomical, magnetic, and meteorological instruments is now in a fair way to become worthy of the institution and the country it represents, and the library is increasing rapidly in the number of volumes and their scientific value.

Among the influences that helped to bring about this auspicious result were, in the first place, the unswerving interest and indefatigable zeal of Mr. John Quincy Adams. Although his suggestions concerning the establishment of a national observatory were treated with neglect during the term of his presidency, he did not lessen his efforts in the cause dear to his heart. In 1838 he presented its claims before President Van Buren, and in 1842 in his place in the House of

Representatives. The report of the committee, presented at this session by Mr. Adams, should be read by every student of astronomy, for the fervor of its eloquence and the nobility of the truths it enunciates. Lieutenant Gilliss was equally unwearied in the cause. It was by his diligent and successful observations that he secured the essential confidence and coöperation of the Navy Department, and of the naval committees. He was the first person, in the United States, who gave his whole time to practical astronomical work. He first published a volume of observations, prepared a catalogue of the stars, and planned and carried into effect the construction of a working observatory, in contrast with one intended simply to teach. For this arduous work he was specially gifted, possessing a wondrous acuteness of the perceptive powers of eye and ear. Prof. Peirce, after examining his observations from 1838 to 1842, gives him the second place in the long list of observers, living and dead, whose results were critically and searchingly tested by the so-called personal scale. Profs. Bartlett, Kendall, and Walker, contributed largely by their labors to the establishment of the institution. Their series of astronomical observations, their publications, and the able report on European observatories, by Prof. Bartlett, in 1840, had a powerful influence in rousing public interest in the subject, and, combining with other influences, produced the desired result.

In 1844 Commander Maury was appointed superintendent of the new observatory, assisted by the same officers who had been attached to the Depot of Charts. Under the instruction of the Secretary of the Navy, the most extensive astronomical work was proposed in cataloguing the stars. The task set before the infant observatory, said a critic in the *North American Review*, was "nothing less than assigning color, position, and magnitude, to every star in the heavens, which could be seen with the instruments." With the resources at the command of the officers at that time, it would have required a century to complete it. The work was, however, commenced of making a catalogue of the stars down to the ninth and tenth magnitude. In 1846 the first volume of observations was issued from the press. In 1847 the observatory was first brought into prominence by the identification of the newly-discovered planet Neptune, with a star of Lalande's catalogue of 1795. Astronomers thus obtained an observation of Neptune made fifty years before, which afforded the means of an accurate determination of its orbit; and the superintendent of the "American Nautical Almanac" was enabled to publish an ephemeris of the new planet two years in advance of all other parts of his almanac. In 1848 the institution first bore the name of "United States Naval Observatory" instead of "National," an honor justly due to the Navy Department which controlled it, and to the navy officers who had charge of its interests. But the preparation and publication of Wind and Current Charts absorbed the attention of the superintend-

ent. With the exception of the equatorial and mural circle-observations, zone-observations, and several years' unpublished work of other observers, regular astronomical work did not receive the prominent attention demanded for the best interests of the observatory. In 1861 Lieutenant Maury left his position to join the cause of the Confederate States of the South.

Captain Gilliss succeeded to the office in 1861. His heart and hand were in the work. He published the volume of observations for 1861 promptly in 1862. He gave detailed statements of the volumes of observations he found unprepared for the press, took measures for their publication, for the regular and prompt issue of annual volumes from the observatory, and arranged that meteorological observations should form a part of each volume. The volume of observations for 1862 contained a discussion concerning the longitude of Washington; a paper on Comet II., 1862, with drawings of the comet during the period of greatest brilliancy; and a plate illustrating the appearance of Mars, near the opposition in that year. The special work for 1863 was an investigation of the solar parallax from observations on the planet Mars. Nearly 11,000 observations were made with four instruments during this year. A transit-circle was also contracted for to improve the defective equipment of the observatory. But, while the field was widening before him, and when neither of his three favorite aims had come to a successful issue, Captain Gilliss was suddenly removed by death, in 1865, from the scene of his labors.

Rear-Admiral Davis was placed in charge of the observatory in 1865. During the same year the great transit-circle was completed, and placed in position in the then west wing of the observatory. This constituted an era in its history, and raised it to a more fitting rank among institutions of its class. The volumes of observations for 1863 and 1864 were published in 1865 and 1866. The meteorological observations from 1842 to 1867 were fully discussed, a report was made on interoceanic canals and railroads, and the regular routine work was diligently kept up. In 1867 Rear-Admiral Davis was ordered to take command of the South-Atlantic Squadron.

In 1867 Rear-Admiral Sands became the fourth superintendent, and is the present incumbent of the office. Since that time the work has so greatly increased in all directions, and the progress of science demands such an amount of labor, that the limits of this article will permit only a brief mention of a few of the most important portions of the work accomplished. One of the recent publications of the observatory is a "Manual of its Founding and Progress," prepared by Prof. Nourse. We refer readers, who desire more extended information, to this able and exhaustive paper, to which we are indebted for our facts and suggestive information. Under the present superintendent, and his efficient and coöperative assistants, the observatory has gone steadily forward, enlarging its boundaries, and widening its field

of vision. The current years have been rich in results in the regular work of the institution, as the published volumes of observations bear testimony. A new observing-room for the transit-circle was erected in the west wing, and the mounting of the circle was completed in 1870. The library was removed to the room previously occupied by it, and now numbers more than 5,000 bound volumes. The total solar eclipses of August 7, 1869, in America, and December 22, 1870, in Europe, were closely observed by parties from the observatory, and full reports of their observations were published.

But the greatest achievement toward raising the observatory to a higher rank among its peers was the successful completion and mounting, in the new tower and dome prepared for it, of the Great Equatorial, in the month of October of the past year. This auspicious event is largely owing to the persevering effort of the superintendent. After repeated representations concerning the necessity of the instrument, Congress made an appropriation of $50,000 for the purpose. The contract was made in August, 1870, with Messrs. Alvan Clark & Sons, of Cambridgeport, Mass. They agreed to construct a refracting telescope, of good definition, and of 26 inches clear aperture, mounted equatorially on the German plan, and supplied with all the appliances that modern science has developed. They required four years to complete it. But the opticians were ahead of their contract, and the observatory is now rejoicing in the absolute possession of the talismanic instrument which has been the object of its ambition.

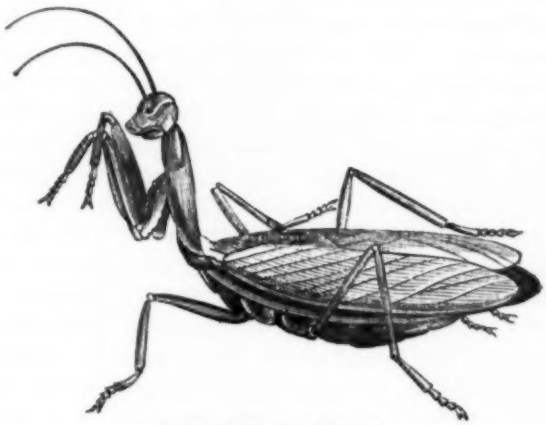
The future work of the institution will demand all its resources. It is already in the full tide of preparation for the observation of the coming transit of Venus in 1874, for which it has received an appropriation of $150,000. It is looking forward to still more satisfactory results from the transit of 1882, which will be specially favorable for observation on American ground, while an opposition of Mars, in 1877, will test the power of its new possession.

With this grand telescope and its equipment, with a *personnel* made up of officers who honor their profession, with Congress ready to grant all needful aid, there is every reason to anticipate a future for the United States Naval Observatory, honorable to itself, and honorable to the country it represents.

THE MANTIS, OR PRAYING INSECT.

SPECIES of insects known as Mantids belong to the order Orthoptera, which includes crickets, grasshoppers, cockroaches, locusts, etc. The following figure illustrates the appearance of one of these. They are of bright, variegated colors, and are sometimes quite large, even three or four inches in length. The mantis lays its eggs at the

end of summer, in rounded, fragile shells, which it attaches to the branches of trees, and which do not hatch till the following summer. It differs in locomotion from its orthopterous relatives, which travel by jumps, while the mantis crawls so slowly that its progress can only be appreciated by careful and prolonged watching. This trait is connected with another character by which the mantis differs from the foregoing groups, for, while they are vegetarians, this insect is carnivorous, and its insidious movements are part of the policy by which it



MANTIS RELIGIOSA (MALE).

captures the various creatures upon which it feeds. But the mantis is not only a carnivore which lives by killing and devouring other insects, it is also a creature of the most quarrelsome disposition; in fact, it is a ferocious cannibal. If two of these insects be shut up together, they engage in a desperate combat; they deal each other blows with their front legs, and do not leave off fighting until the stronger has succeeded in eating off the other's head. From their very birth the larvæ attack each other. In their contests, the male, being smaller than the female, is often the victim. This pugnacity of the mantis is the source of amusement to children in China. Two mantids are shut up together in a bamboo cage, and the young heathen view with delight the inevitable battle, and the resulting cannibal feast.

And yet, while its inoffensive orthopterous brethren have got but little credit for their virtues, and are generally reviled as nuisances, this atrocious little savage has had the fortune to acquire a peculiar reputation for wisdom and saintliness. For thousands of years, and in all parts of the world, it has borne this character. The cause has been that it habitually assumes an attitude that appears devotional, and it was supposed to spend a large portion of its life in prayer. Settled on the ground, it raises its head and thorax, clasps together the joints of its front legs (see cut), and raises them as if in supplication, and remains in this posture for hours together. To our illogical and superstitious

forefathers what could the upraised and crossed arms indicate but an attitude of devotion?

The name *mantis* (diviner) was given to this insect, it is said, by the Greeks, in accordance with the notion that, when the creature assumes its peculiar attitude of meditation, it is engaged in the contemplation of futurity. Naturalists have encouraged the superstition by giving names to the different species which imply some kind of sanctity; thus, we have Mantis oratoria, Mantis religiosa, Mantis superstitiosa, etc. With the French it is the Prega-Dieu (that prays to God), Le Prêcheur (the preacher); with the Germans it is Gottesanbeterin (worshiper of God), while the English-speaking nations have dubbed it the Praying Insect. The names familiarly given to it in Southern Europe are sufficiently expressive of the veneration with which it is regarded—nun, saint, suppliant, mendicant, etc. "In the eyes of the Languedoc peasants," says Figuier, "the Mantis religiosa is held sacred, and they firmly believe that it performs its devotions." Mr. Spicer, writing in *Science Gossip*, remarks: "Nor was this feeling of veneration confined to the nations of Europe. At the present day (and doubtless it was the same in old times also) a Mantis is an object of worship with certain tribes of North Africa." Sparmann also tells us ("Travels in Africa") that "in the southern part of the same continent it is venerated by the Hottentots; and that, should one of these insects chance to settle on an individual, he is looked upon in the light of a saint, and as specially favored by Heaven."

That the superstition should have gone to greater lengths than mere inference was natural: somebody was certain to make the mantis open his mouth and give audible expression to his devout sentiments. Of course we should expect this in the middle ages, when credulity was unbounded, and there was a universal belief in the semi-divine nature of this wicked bug. "The great Saint Francis Xavier is said to have held a conversation with one which he came across in a forest, and to have induced it to chant a hymn!"

Dr. James Mann, author of the "Guide to the Knowledge of Life," and who was for some years superintendent of education in the province of Natal, South Africa, has written a very interesting account of the insects of that region, which was published in the *Intellectual Observer*, and from that article we quote the following passage regarding the mantis, from which it will be seen that the insect still contrives to keep up its theological reputation: "Of orthopterous Natal insects, the large green mantis is certainly a distinguished chief. He is a very remarkable fellow, powerful alike upon wing and leg, but much given to fits of lethargy and brown study. His traditional religious exercise, indeed, is simply a lying in wait for what the gods may send in the way of food. He fixes himself, as if in rapt contemplation, upon some convenient stalk or leaf, and then bends up his chest and shoulders into an almost erect position, pressing together his arms in front,

and looking well out before him, with the palpi of his lips slightly vibrating. In this expectant mood he allows himself to be coaxed with the finger, merely staggering back a pace or two, and fixing his goggle-eyes upon the biped who vouchsafes this personal attention. If he lights upon a perpendicular window or wall when in this vein of 'religious' ecstasy, he seems to remain for hours together without motion, but all the while he mounts imperceptibly up and up until he reaches the ceiling or roof which limits the chamber in the upward direction. The closest watching does not show how this most gradual of all climbings is accomplished. Not a limb can be seen to move, yet up, minute after minute, he glides. It is while he is in these fits of expectant ecstasy that he seizes his prey. He is essentially a carnivorous feeder, and pounces stealthily upon any unwary insect that settles within convenient reach, seizing the victim between his upraised legs, and fixing it there between the row of spikelets with which these prehensile limbs are fringed. After a deliberate inspection of the morsel held in this position, he goes to work with his jaws. . . .

"It was the author's fate upon one auspicious occasion," writes Dr. Mann, "to watch one of these 'religious' insects engaged in a remarkably appropriate occupation. A dignitary of the Natal Church, who has since made some noise in the world (Bishop Colenso), was, one warm summer evening, with all the windows and doors of his chapel open to the refreshing breeze, preaching by candle-light, when a huge green mantis whizzed into the assembly and perched himself upon the preacher's white neckerchief; and, first folding his arms into the prayerful attitude, he raised his chest and shoulders into rapt attention, turning his goggles from side to side, and following responsively each motion of the spectacles, that glanced, now on this hand and now on that, from above. He remained fixed in this convenient position until properly dismissed with the rest of the congregation at the close of the sermon, and he did not even then depart at once, being puzzled and staggered, in all probability, by some of the novel doctrines he had been listening to."

EVOLUTION AND THE ORIGIN OF LIFE.

By H. CHARLTON BASTIAN, M.D., F.R.S.

YEAR by year the word "Evolution" becomes diffused more widely through our literature, and the central idea which it implies grows familiar to an ever-increasing multitude of readers. We have witnessed within the last few years a marvelous awakening of interest in the minds of the public generally to questions of science, and it so happens that a discussion of the doctrine of Evolution has

been more or less directly involved in those departments of Science and Philosophy which have during this period received the largest share of popular attention.

Perhaps the greatest impetus was given to the spread of the doctrine about fourteen years ago, by the publication of Mr. Darwin's now celebrated "Origin of Species." This volume has been followed by quite a library of works and memoirs on the same subject—partly scientific and partly popular. From about the same date also, Mr. Herbert Spencer has been engaged in systematically elaborating the principles of an all-comprehensive Evolution Philosophy, and the results of his genius and labor are now undoubtedly influencing the thoughts of a rapidly-widening circle of readers. Both in this country and abroad, the doctrine of Evolution is gradually but surely gaining ground among the most reflective; and, although many other writers have been more or less influential in determining this result, it has been in the main brought about by the two above mentioned.

Evolution implies continuity and uniformity. It teaches us to look upon events of all kinds as the products of continuously-operating causes—it recognizes no sudden breaks or causeless stoppages in the sequence of natural phenomena. It equally implies that natural events do not vary spontaneously. It is a philosophy which deals with natural phenomena in their widest sense; it embraces both the present and the far distant past. It seeks to assure us that the properties and tendencies now manifest in our surrounding world of things are in all respects similar to those which have existed in the past. Without a basis of this kind, the Evolution hypothesis would be a mere idle dream. Uniformity is for it an all-pervading necessity. Starting from facts of daily observation and from scientific experiments, the properties and tendencies of things are noted and grouped; while philosophers, using the knowledge thus gained, seek to trace back the progress of events and show how this complex world has gradually been derived from a world of more and more simple composition. We are taken back in imagination even much farther. We are referred to a primal haze or nebula—as the gigantic germ of a future Universe. This was the conception of Laplace.

But whether we follow the philosopher in his bold speculations concerning the past, or listen to the biologist making his predictions concerning the future stages which the germ of a given animal will pass through in the progress of its evolution — in each case the "uniformity of Nature" is tacitly assumed. This assumption underlies almost all our thoughts and actions, even in every-day life. And, without such a belief in the Uniformity of Nature, science would be impossible—the very idea of it, in fact, could never have arisen. In its absence we could neither fathom the past nor illumine the future. As Mr. Mill said[1]—"Were we to suppose (what it is perfectly possi-

[1] "System of Logic," sixth edition, vol. ii., p. 98.

ble to imagine) that the present order of the universe were brought to an end, and that a chaos succeeded in which there was no fixed succession of events, and the past gave no assurance of the future, if a human being were miraculously kept alive to witness this change, he surely would soon cease to believe in any uniformity, the uniformity itself no longer existing."

It is true that in earlier times no absolute belief in the uniformity of Nature existed, even among the select few. The Greek philosophers, including Aristotle, recognized "chance" and "spontaneity" as finding a definite place in Nature, and to this extent they were not sure that the future would resemble the past. But as we have become more familiar with a wider range of natural phenomena, and with their mutual relations or order of appearance, so has the conception of chance or spontaneity disappeared from the scientific horizon—driven out of the field by the steady advance of Law and Order. Those who embrace the Evolution philosophy are foremost in this opinion—they believe that no effects of whatsoever kind can occur without adequate causes, and, the conditions being similar, that the same results will always follow the action of any given cause. Their whole creed is, in fact, preëminently based upon this assumed uniformity of Nature.

The present is essentially a time of transition in matters of opinion. Men who have been educated in one system of beliefs are gradually being converted to another, because the new system is thought to be more harmonious with the observed order of natural phenomena. This has been the case even with the chief exponents of Evolution. They have themselves had to unlearn much which they had previously learned. The doctrine of Evolution has thus been developed only by the sacrifice of many previous early beliefs and modes of thought. But it often happens that an old belief will—unknown, perhaps, to the person himself—leave decided traces of its previous influence, and thus prevent for a time the full realization of all the logical consequences of new views. This vestige of the old state of opinion or habit of thought is, more especially, apt to remain in directions where unexplained facts, or strong prepossessions and prejudices, bar the way. Some modes of this inconsistency may become obvious to one worker or thinker, and some to another, according to the particular direction which his investigations or thoughts may have taken; and such inconsistencies should be pointed out as they present themselves. So that, with the view of strengthening an hypothesis which I, in common with so many other workers in science, believe to be true, I now venture to allude to certain apparent anomalies in the declared opinions of the most prominent upholders of the doctrine of Evolution in this country. It seems all the more desirable that this should be done, since the inconsistencies may be easily shown to be wholly uncalled for, and to involve sundry unscientific conceptions.

Yet the modifications of opinion which appear to be demanded, on the ground of fact as well as on the ground of reason, will necessitate very considerable and almost revolutionary changes in the accepted code of biological doctrines.

An examination of the facts of science generally and of various every-day phenomena teaches us, according to the Evolutionist, that matter of different kinds, situated as it is and has been, gradually tends within certain limits to become more and more complex in its internal and external constitution. Coupling this conclusion with various astronomical data, with geological data, and with facts derived from the study of the past forms of Life upon our globe, the Evolutionist essays to penetrate through the long vista of by-gone ages, till he may rest his speculative gaze upon a vast rotating nebular mass of gaseous matter, of comparatively simple though unknown constitution, from which he supposes our Universe to have been slowly evolved. Without futile questionings as to the explanation or cause of the existence of the nebula, without speculation as to what simpler or more complex matter may have immediately preceded it, it is obvious that we may for our own convenience take up its imaginary existence at any stage. Though we must be free to admit that in concentrating our attention upon this nebular stage, or upon any other, we arbitrarily break into a mysterious cycle of existence whose Cause is to us unfathomable. It is needless for my purpose, however, to attempt to concentrate the reader's attention upon a period so remote in the history of our Universe. The primordial nebula, as it cooled and condensed, acquired a more rapid axial rotation: masses were gradually thrown off from its circumference, and these in their turn condensed into rotating spheroids, which continued to circulate round the parent mass in elliptical orbits. Assuming, then, with the Evolutionist, that our own planet had a past history of this kind, we must also assume that it gradually changed from a gaseous to a fluid state before beginning to solidify by the formation of a superficial crust—a crust which gradually thickened as the fervent heat of it and of the fluid nucleus abated by heat-radiations into space. Until this stage of the Earth's history had been far advanced, no Living Things could have existed upon its surface. "Hence," as Sir William Thomson said,[1] "when the Earth was first fit for life there were no living things on it. There were rocks, solid and disintegrated, water, air all round, warmed and illuminated by a brilliant sun, ready to become a garden." Living things must, however, have appeared upon its surface at some very remote epoch, since their remains are to be found far down in the rocks which at present constitute its crust. But how, it must be asked, is the first appearance of living matter upon the earth to be accounted for?

We should not needlessly invoke an abnormal act of Creative

[1] Inaugural Address at Meeting of British Association, *Nature*, August 3, 1871, p. 269.

Power, we must not even resort to a "moss-grown fragment from the ruins of another world," unless it is really necessary to invent some such hypothesis. Now, the Evolutionist repudiates the notion of Creation in its ordinary sense; he believes that the operation of natural causes, working in their accustomed manner, was alone quite adequate to bring into existence a kind of matter presenting a new order of complexity, and displaying the phenomena which we have generalized under the word "Life." Living matter is thus supposed to have come into being by the further operation, under new conditions, of the same agencies as had previously led to the formation of the various inorganic constituents of the earth's crust—such mineral and saline substances as we see around us at the present day. What we call "Life," then, is regarded as one of the natural results of the growing complexity of our primal nebula. So that, in accordance with this view, we have no more reason to postulate a miraculous interference or exercise of Creative Power to account for the evolution of living matter in any suitable portion of the Universe (whether it be on this earth or elsewhere), than to explain the appearance of any other kind of matter—the magnetic oxide of iron, for instance. So far, all thorough Evolutionists are quite agreed. This is the view of Spencer, Lewes, Huxley, and others—possibly of Darwin. I say possibly of Darwin, because on this subject it so happens that the language of this most distinguished exponent of Evolution is more than usually tinctured with a previous point of view. Speaking of the probable commencement of Life upon our globe, Mr. Darwin says[1]: "I believe that animals have descended from at most only four or five progenitors, and plants from an equal or lesser number. Analogy would lead me one step farther, namely, to the belief that all animals and plants have descended from some one prototype. . . . There is grandeur in this view of life, with its several powers, having been originally breathed by the Creator into a few forms, or into one; and that while this planet has gone cycling on according to the fixed law of gravity, from so simple a beginning endless forms, most beautiful and most wonderful, have been and are being evolved." Taking into account the phraseology made use of in the above quotation, we have little difficulty in recognizing the views of an Evolutionist, dwarfed and modified though they are by an ultimate appeal to a Creative act only a little less miraculous and singular than the mythical origin of our reputed ancestors—Adam and Eve. Some existing naturalists may perhaps contend that Mr. Darwin ought to have kept more closely to the Mosaic record—replacing his one primordial form by a dual birth of male and female, without whose mutual influence no "biological individuals" can in their opinion come into existence. Such a supposition, it is true, would be as antiquated and unnecessary from the Evolutionist's point of view as

[1] "Origin of Species," sixth edition, 1872, pp. 424, 429.

is the whole notion of life having been originally "breathed" into one or more organic forms. Mr. Spencer's language is happily free from both these defects: he neither uses the phraseology of the Creative hypothesis, nor does he adopt a definition of biological "individuality," at variance with the Evolution philosophy. He distinctly teaches that living matter must have been at first formless, and that multiplication would have taken place, as among the lowest forms of the present day, exclusively by agamic methods — nay, more, he teaches that living matter must have been the gradual product or outcome of antecedent material combinations. "Construed in terms of evolution," he says,[1] "every kind of being is conceived as a product of modifications wrought by insensible gradations on a pre-existing kind of being, and this holds fully of the supposed 'commencements of organic life,' as of all subsequent developments of organic life." But on the question whether the process of Archebiosis (life-evolution) is likely to have occurred once only, as Mr. Darwin seems to hint, or in multitudinous centres scattered over the earth's surface, Mr. Spencer makes no definite statement. The latter belief would, however, be entirely in accordance with his general doctrine; and we seem all the more entitled to infer that Mr. Spencer inclines to the notion of a multiple occurrence of Archebiosis, both in space and in time, since he does not reject the possibility of its occurrence in our own day. Granting "that the formation of organic matter and the evolution of life in its lowest forms may go on under existing cosmical conditions," he believes it "more likely that the formation of such matter and of such forms took place at a time when the heat of the earth's surface was falling through those ranges of temperature at which the higher organic compounds are unstable." But conclusions which we are only able to infer from the writings of Mr. Spencer have been distinctly enunciated by Mr. G. H. Lewes. In a criticism of the "Darwinian Hypothesis," he very forcibly pointed out that it is quite compatible with the hypothesis of evolution to admit a variety of starting-points for the formation of living matter, and he consequently laid down in principle a very important extension of the Darwinian doctrine, in its application to higher organisms. He says:[2] "Although observation reveals that the bond of kinship does really unite many divergent forms, and the principle of Descent with Natural Selection will account for many of the resemblances and differences, there is at present no warrant for assuming that all resemblances and differences are due to this one cause, but, on the contrary, we are justified in assuming a deeper principle which may be thus formulated: All the complex organisms are evolved from organisms less complex, as these were evolved from simpler forms: the link which unites all organisms is not always the common bond of heritage, but the *uniformity of organic laws acting under uniform condi-*

[1] "Principles of Biology," vol. ii., Appendix, p. 482. [2] *Fortnightly Review*, 1868.

tions. . . . It is therefore consistent with the hypothesis of Evolution to admit a variety of origins or starting-points." In this paper Mr. Lewes distinctly postulates the probability of a repetition of the process of Archebiosis, wherever the conditions were favorable, and though he says nothing against the continuance of such a process in the present day, neither does he dwell upon it as a probability.

Prof. Huxley's[1] opinions on the subject of Archebiosis are very similar to those of Mr. Spencer, with the exception that he seems more strongly opposed to the notion of its occurrence at the present day, and it is to this aspect of the question that I would now direct the reader's attention. Why should men of such acknowledged eminence in matters of Philosophy and Science as Mr. Herbert Spencer and Prof. Huxley promulgate a notion which seems to involve an arbitrary infringement of the uniformity of Nature?

They would both have us believe that living matter came into being by the operation of natural causes—that is, by the unhindered play of natural affinities operating in and upon matter which had already acquired a certain degree of molecular complexity. They believe that the simpler kinds of mineral and crystalline matter continue to come into being now as they have ever done; nay, more, they believe that the higher kind of matter, originally initiated by the operation of natural causes, continues to grow both in animal and in vegetal forms, solely under similar influences, and yet they consider themselves justified in supposing that natural causes are now no longer able independently to initiate this higher kind of matter (protoplasm). We find Prof. Tyndall[2] also affirming, in the most unhesitating language, the ultimate similarity between crystalline and living matter: affirming that all the various structures by which the two kinds of matter may be represented are equally the "results of the free play of the forces of the atoms and molecules" entering into their composition. And he, too, would have us believe that, while differences in degree of molecular complexity alone separate living from not-living matter, the physical agencies which promote the growth of living matter are now incapable of causing its origination.

Why, we may fairly ask, should a supposed difference be erected by Evolutionists between Origination and Growth in the case of living matter, while no one dreams of making any such distinction in reference to crystalline matter? Is it true that the process of growth differs from the process of origination, and if so in what respects? Philosophically speaking there is little difference. Take the case of the formation of the "silver tree," cited by Prof. Tyndall. A weak galvanic current is passed through a solution of nitrate of silver, and simultaneously, in a first increment of time, a number of molecules of

[1] "Inaugural Address at Meeting of British Association," *Nature*, September 15, 1870, p. 404.

[2] "Fragments of Science," fourth edition (1872), pp. 85–87, and 113–119.

oxygen and of silver begin to aggregate independently into crystals of oxide of silver; in a second increment of time the operation of the same causes produces similar results, only now part of the new crystalline matter forms in connection with the preëxisting germs of crystals, though part of it may still aggregate independently. During a third, a fourth, and in all succeeding increments of time, in which the same causes operate amid similar conditions, similar results must ensue. But, taking the process of origination which occurs in the first increment of time, would Prof. Tyndall have us believe that it is in any way different from that of growth which takes place in a second, third, or fourth increment of time? Does not the very fact that origination and growth so often occur simultaneously in the case of crystalline matter, and under the influence of the same causes, show us that the two processes are intrinsically similar, and that conditions favorable for growth are also likely to be favorable for origination? And if this be true for crystalline matter, may we not infer that it would also be true for living matter? These are questions neither asked nor answered in any definite manner by those whose opinions I have already cited. They are, however, questions by no means unworthy of an attentive consideration.

Although, as a general rule, conditions favorable for the growth of any particular kind of crystalline matter are likely to be favorable for its origination, still it must be acknowledged that the presence of a crystal will occasionally lead to its growth in a medium in which similar crystalline matter had previously shown no tendency to form independently—even in cases where the introduction of a non-crystalline nucleus would not be able to determine a similar formation of crystalline matter. In spite of the general law, therefore, that conditions favorable for the growth are also favorable for the origination of crystalline matter, we are compelled to admit that growth may be determined under certain conditions where origination does not occur, and that the presence of preëxisting crystalline matter favors the process. Now, a distinction of the same kind undoubtedly obtains in the case of living matter. We know, quite positively, that, although Bacteria will not originate in a previously-boiled ammonic tartrate solution, or "Pasteur's solution," the addition of a few of these organisms (all other conditions remaining the same) will soon occasion a very considerable growth of the living matter of which they are composed.[1] We are thus reduced to ask whether the influence of the preëxisting nucleus is relatively more potent in the case of living matter than it is in the case of crystalline matter? This is a question which unfortunately we are unable definitely to answer. But, so long as we have no positive knowledge on this subject, we surely have little right to infer that processes both of origination and of growth continue in the case of crystalline matter, while the process of growth alone survives in the

[1] "The Beginnings of Life," vol. i., p. 325.

case of living matter. There are no facts easily discoverable upon which such an assumption can be legitimately based.

The probabilities would seem altogether in favor of the continuance of a natural process like Archebiosis after it had been once initiated, more especially when this natural process is so closely allied to another which manifests itself with the utmost readiness on all parts of the earth's surface. So that, unless very cogent reasons could be adduced against the occurrence of Archebiosis at the present day, looked at from an *a priori* point of view, there seems scarcely room for doubt upon the subject. The properties and chemical tendencies of material bodies seem to be quite constant through both time and space. Speaking upon this subject in a recent discourse on "Molecules," Prof. Clarke Maxwell says:[1] "We can procure specimens of oxygen from very different sources, from the air, from water, from rocks of every geological epoch. The history of these specimens has been very different, and, if, during thousands of years, difference of circumstances could produce difference of properties, these specimens of oxygen would show it. . . . In like manner, we may procure hydrogen from water, from coal, or, as Graham did, from meteoric iron. Take two litres of any specimen of hydrogen, it will combine with exactly one litre of any specimen of oxygen, and will form exactly two litres of the vapor of water. . . . Now, if, during the whole previous history of either specimen, whether imprisoned in the rocks, flowing in the sea, or careering through unknown regions with the meteorites, any modification of the molecules had taken place, these relations would no longer be preserved. . . . But we have another and an entirely different method of comparing the properties of molecules. The molecule, though indestructible, is not a hard, rigid body, but is capable of internal movements, and, when these are excited, it emits rays, the wave-length of which is a measure of the time of vibration of the molecule. . . . By means of the spectroscope the wave-lengths of different kinds of light may be compared to within one ten-thousandth part. In this way it has been ascertained, not only that molecules taken from every specimen of hydrogen in our laboratories have the same set of periods of vibration, but that light having the same set of periods of vibration is emitted from the sun and from the fixed stars. . . . We are thus assured that molecules of the same nature as those of our hydrogen exist in those distant regions, or at least did exist when the light by which we see them was emitted." With evidence such as this before us, which could be multiplied to an enormous extent, we should hesitate before needlessly postulating any infringement of the uniformity of natural phenomena.

What, then, are the reasons assigned for the non-occurrence, at the present day, of the process of Archebiosis? All that Mr. Spencer says upon the subject is, that such a process seems to him more likely

[1] *Nature*, September 25, 1873, p. 440.

to have occurred at "a time when the heat of the earth's surface was falling through those ranges of temperature at which the higher organic compounds are unstable," than at the present day. Why such conditions would be more favorable than those now existing Mr. Spencer does not say; and that such an alteration should suffice to put a stop to Archebiosis, although we see living matter still growing freely all over the earth under the most diverse conditions as regards temperature, seems very difficult to believe. Yet no other suggestion is offered in explanation of an assumption which seems essentially unscientific. For the assumption that Archebiosis took place only in the remote past puts this process on a *quasi* miraculous level, and tends to assimilate it to an act of special creation, the very notion of which Mr. Spencer, in other cases, resolutely rejects.

Again, what reason does Prof. Huxley give, in explanation of his supposition as to the present non-occurrence of Archebiosis? He says[1] if it were given to him "to look beyond the abyss of geologically-recorded time," to a still more remote period of the earth's history, he would expect "to be a witness to the evolution of living protoplasm from non-living matter." And the only reason distinctly implied why a similar process should not occur at the present day is, because the physical and chemical conditions of the earth's surface were different in the past from what they are now. And yet, concerning the exact nature of these differences, and the degree in which the different sets of conditions would respectively favor the occurrence or arrest of an evolution of living matter, Prof. Huxley cannot possess even the vaguest knowledge. He chooses to assume that the unknown conditions existing in the past were more favorable to Archebiosis than those now in operation. This, however, is a mere assumption which may be entirely opposed to the facts. It is useless, of course, to argue upon such a subject, but still it might fairly be said, in opposition to his assumption of the impotency of present telluric conditions, that the abundance of *dead organic matter* now existing in a state of solution would seem to afford a much more easy starting-point for life-evolution than could have existed in that remote past, when no living matter had previously been formed, and consequently when no dead organic matter, thence derived, could have been diffused over the earth's surface.[2]

Prof. Huxley is, however, very inconsistent, since, in spite of his declared expectation of witnessing the evolution of living from lifeless matter, if it were given him "to look beyond the abyss of geologically-recorded time," he had said, scarcely five minutes before, in reference to experimental evidence bearing upon the present occurrence of a

[1] *Nature*, September 15, 1870, p. 404.

[2] This is a consideration of great importance, since those who believe that Archebiosis occurs in organic solutions at the present day have not yet professed to show that it can occur in saline solutions free from all traces of organic matter.

similar process, that, "if, in the present state of science, the alternative is offered us—either germs can stand a greater heat than has been supposed, or the molecules of dead matter, *for no valid or intelligible reason that is assigned*, are able to rearrange themselves into living bodies, exactly such as can be demonstrated to be frequently produced in another way—I cannot understand how choice can be, even for a moment, doubtful." Having thus expressed himself, it was a little strange that Prof. Huxley forgot to inform his audience, five minutes afterward, what "valid or intelligible reason" he was able to assign for the occurrence of that evolution of non-living matter into living protoplasm in the remote past to which he alluded. A supernatural interposition of Creative Power would explain the presence of living things upon our earth, just as easily as a supernatural preservation of living matter from the destructive effects of heat would account for the presence of living organisms within certain experimental flasks. But Prof. Huxley most inconsistently says that, even in the face of scientific evidence concerning the destructive powers of heat upon living matter, he would rather explain the presence of organisms in certain flasks on the hypothesis of a (supernatural) preservation of germs, than believe in the otherwise proved occurrence of a present life-evolution, similar to that which he assumes to have taken place in the past. He is willing to accept the supernatural in the present, though he declines to interpret the past by its aid. He assumes this attitude because no "valid or intelligible reason" is assigned in explanation of life-evolution, a belief in which would render unnecessary any appeal to the supernatural in the present; though he himself postulates the occurrence of the same unexplained process in the past, solely in order to avoid recourse to the supernatural. Prof. Huxley's position in reference to this question is very puzzling, and one cannot help wondering through what monochromatic glass he had been taking his observations (from his "watch-tower"), in order to come to the conclusion that "the present state of science" gives any sanction to such vacillations, or entitles him to appeal to a supernatural preservation of germs, instead of trusting to the known uniformity of natural phenomena.

Sir William Thomson was certainly much more consistent. He, too, seemed inclined to explain the experiments of our own day by resorting to the hypothesis of a supernatural preservation of germs, and similarly, he seems not unwilling to explain the original advent of Life upon this globe, by another assumed process of "Contagion." He has resort neither to a creative hypothesis nor to the hypothesis of a natural becoming of living matter, but, shelving the question of "origin" altogether, he suggests that our earth may have become peopled with organic forms, owing to the advent upon it, in the remote past, of a "moss-grown fragment from the ruins of another world." Sir William Thomson's hypothesis seems strangely improb-

able in itself, though it has, in comparison with the views of others, the somewhat rare merit of being not inconsistent with his notions concerning the experiments of to-day. He does not reject the supernatural in the past, while resorting to it for the present—he resorts to it in the present and in the past alike, and curiously evades the problem of origin altogether.

Since so little—or, rather, nothing—is said by Prof. Huxley in support of his supposition that living matter does not originate in the present day, even though the process of origination is so closely akin to that of growth; and, though the process of growth is taking place at every moment of our lives, in every region of the globe, and under the most varied conditions—amid tropical heat and icy coldness, on mountain-tops and deep down in almost unfathomable ocean-beds—it seems only reasonable to suppose that he must have been influenced by some prepossessions. And, so far as one can gather from his presidential address before the British Association—from which I have already quoted—he does not appear to have been powerfully biased by theoretical considerations. One of these we shall now consider.

Much stress is laid by certain writers upon the fact that "the doctrine of spontaneous or equivocal generation has been chased successively to lower and lower stations in the world of organized beings, as our means of investigation have improved."[1] So that, as another very eminent writer says, "if some apparent exceptions still exist, they are of the lowest and simplest forms."[2] And it is usually inferred from this fact that further knowledge and improved means of observation will prove these apparent exceptions to be no exceptions to the supposed general rule—*omne vivum ex vivo*. A consideration of this kind seems to have powerfully influenced Prof. Huxley. But much confusion exists in reference to the point, which needs to be removed. In the first place, it must be freely admitted that many ancient notions, dating from the time of Aristotle, on the subject of "Equivocal or Spontaneous Generation," were altogether crude and absurd. Secondly, it is necessary to distinguish (and Prof. Huxley did so) between two meanings of the phrase, which have often been confounded with one another—viz., between Heterogenesis, or the mere allotropic modification of already existing living matter, and Archebiosis, or the independent origination of living matter. Thirdly, it should be distinctly understood that those who strictly adhere to the Evolution hypothesis could never believe in the origination of any but the "lowest and simplest" organic forms by a process of Archebiosis. So that, as Prof. Huxley professes himself an Evolutionist, the objection above indicated should have been quite pointless for him. Molecular combinations, giving rise to units of protoplasm far below the *minimum*

[1] Prof. Lister, "Introductory Lecture" (University of Edinburgh), 1869, p. 12.

[2] Mr. Justice Grove ("Presidential Address"), Report of British Association for the Advancement of Science, 1866, p. 71.

visible stage of our most powerful microscope, would represent those initial collocations by which alone living matter could come into being —though the "germs" thus initiated may afterward appear as minutest visible specks growing into Bacteria, Vibriones, or Torulæ. We may, therefore, be permitted to remark that, even if it were given to Prof. Huxley to "look beyond the abyss of geologically-recorded time," he would be extremely unlikely to witness an "evolution of living protoplasm from not-living matter." At the most, he might see (that is, if equipped with a powerful microscope) only what he may equally well see now—viz., a gradual emergence into the sphere of the visible of minute specks of living protoplasm. But though *he* might, when looking back to this remote age, be inclined to consider such appearances as testifying to the evolution of living protoplasm from not-living matter, he would perchance find it just as difficult to convince others of the absence of invisible Salamandrine germs (derived, perhaps, from the "moss-grown fragment of another world") as he is himself difficult to be convinced by similar appearances at the present day. Prof. Huxley seems, for the time, to have lost sight of a consideration justly deemed by Prof. Tyndall to be one of great importance in the interpretation of evolutional phenomena—viz., the enormous difference in point of size between the first constituent molecules of protoplasm and the minutest visible organisms. As Prof. Tyndall puts it, compared with their constituent elements, "the smallest vibrios and bacteria of the microscopic field are as behemoth and leviathan," even though the latter are often less than $\frac{1}{30000}$ of an inch in diameter.

Thus it would appear that a consistent belief in the Evolution hypothesis necessarily carries with it a belief in the continuance of the process of Archebiosis from the remote epoch when living matter first appeared upon this earth down to the present time. The Evolutionist teaches us that living matter is not in its essence different from other kinds of matter, and that it originally came into being, like the various forms of mineral and crystalline matter, by the operation of mere natural causes. As Prof. Huxley says:[2] "Carbon, hydrogen, oxygen, and nitrogen, are all lifeless bodies. Of these carbon and oxygen unite in certain proportions and under certain conditions to give rise to carbonic acid; hydrogen and oxygen produce water; nitrogen and hydrogen give rise to ammonia. These new compounds, like the elementary bodies of which they are composed, are lifeless. But, when they are brought together under certain conditions, they give rise to the still more complex body, protoplasm; and this protoplasm exhibits the phenomena of life." So that, if living matter has once arisen naturally and independently, the laws of uniformity alone, upon which all science is based, should lead us to expect

[1] "Fragments of Science," fourth edition, 1872, p. 151.

[2] *Fortnightly Review*, February, 1869.

that it would continue to have a similar "origin" so long as such matter continued to "grow" under the most varied conditions upon and beneath the earth's surface. And, these conditions being fulfilled, we have a good *a priori* warrant for the belief that living matter is continually coming into being by virtue of the operation of the same "laws" or molecular properties as suffice to regulate its growth.

Let the Evolutionist attempt to deny it, and see what other difficulties he plunges into, in addition to that lack of consistency which I have already pointed out.

If an evolution of living matter occurred only far back beyond the depths of geologically-recorded time, and if, as Mr. Darwin[1] would have us believe, "all the living forms of life are the lineal descendants of those which lived long before the Cambrian epoch," how is the Evolutionist to explain the existence of the multitudinous myriads of lowest and almost structureless organisms which exist at the present day? He starts, in his argument in favor of Evolution, from the fact that the condition of homogeneity is one of necessarily unstable equilibrium. All homogeneous matter inevitably tends to become heterogeneous, and, of the different kinds of matter, none unites within itself the various qualities tending to favor this passage from the homogeneous to the heterogeneous in the same degree as living matter. These tendencies are daily exemplified to us by the phases of embryonic development passed through by the more or less homogeneous germs of multitudinous complex organisms from which they proceed. The embryonic development of one of the higher animals—of man himself, for instance—is a kind of highly-condensed epitome of animal evolution in general. And the varied forms of life of higher organization, both animal and vegetal, which have existed and still exist upon the surface of our earth, are all supposed by the Evolutionist to have arisen by dint of insensible modifications wrought through the long lapse of ages upon successive generations of organic forms. But if living matter contains within itself the potentiality of undergoing such mighty changes and of ever growing in complexity—if from originally structureless protoplasm (that is, structureless, to our senses) all the varied forms of life have been derived, how is it that some of this very same matter should have remained through the long lapse of ages almost in its primitive structureless condition?[2] Why should one portion of the living matter which came into being in pre-Cambrian epochs have passed through such marvelous changes, while another portion has continued to grow, through all the inconceivably numerous generations which must have occurred between that time and the present, without undergoing change?

In other words, what is the meaning of the existence of Bacteria,

[1] "Origin of Species," sixth edition, p. 428.

[2] The multiplication of the lowest forms of life takes place so simply that, as Prof. Huxley has pointed out, it is nothing more than a process of "discontinuous growth."

Torulæ, Amœbæ, and such simplest organisms at the present day?[1] Mr. Spencer saw this difficulty, but apparently did not fully realize its force. He attempts, as it appears to me, very inconsistently to evade it by supposing that living matter may escape increasing organization so long as it can escape the influence of gross changes in external conditions; and, just as inconsistently, he assumes that living matter could escape these changes in external conditions through that long lapse of ages which the lowest estimate regards as a period of no less than 100,000,000 years. Speaking of what he presumes to be ancient though almost structureless organisms, and endeavoring to account for their stationary condition as regards structure, by supposing that they have succeeded through long ages in "dodging" all changes in their environment, Mr. Spencer says: "New influences are escaped by the survival of species in the unchanged parts of their habitats, or by their spread into neighboring habitats which the change has rendered like their original habitats, or by both."

Now, in opposition to these views of Mr. Spencer, many very cogent objections may be alleged. In the first place, in supposing that the organization of living matter would not increase even through ages of time unless it were subject to marked variations in external conditions, Mr. Spencer makes a supposition which seems notably at variance with his own doctrines of Evolution. Does he not for a time ignore those internal causes of change which must ever be in operation within living matter as within all other kinds of matter—and which, even in combination with approximately fixed external conditions, should suffice to produce a continually-increasing differentiation (organization) in living matter? Mr. Spencer himself says:[2] "All finite forms of the homogeneous—all forms of it which we can know or conceive—must inevitably lapse into heterogeneity. In three several ways does the persistence of force necessitate this. Setting external agencies aside, each unit of a homogeneous whole must be differently affected from any of the rest by the aggregate action of the rest upon it. The resultant forces exercised by the aggregate on each unit, being in no case alike both in amount and direction, cannot produce like effects on the units. And the various positions of the parts in relation to any incident force preventing them from receiving it in uniform amounts and directions, a further difference in the effect wrought on them is inevitably produced." Even this is not all; Mr. Spencer also points out that "every differentiated part is not simply a seat of further differentiations, but also a parent of further differentiations; since, in growing unlike other parts, it becomes a centre of unlike reactions on incident forces, and, by so adding to the diversity

[1] Especially when Mr. Darwin says: "Judging from the past, we may safely infer that not one living species will transmit its unaltered likeness to a distant futurity."—"Origin of Species" (1872), sixth edition, p. 428.

[2] "First Principles," second edition, pp. 429, 548.

of forces at work, adds to the diversity of effects produced. This multiplication of effects is proved to be similarly traceable throughout Nature." Now, if causes like these are inevitably at work upon and within the simplest forms of life, no change in external conditions would be needed in order to insure an increasing complexity of structure, through months or years, to say nothing about long ages of time. But, as a matter of fact, granting that the liability of organisms to increase in complexity of structure "arises from the actions and reactions between organisms and their fluctuating environments," and seeing that these changes in the environment are enumerated by Mr. Spencer as being due to "astronomic, geologic, meteorologic, and organic agencies," organisms never could by any possibility shelter themselves through long ages of time even from the influence of these external inciters of change. Mr. Spencer's explanation of the cause of the existence of multitudinous almost structureless organisms at the present day, therefore, entirely falls to the ground. The lowest organisms can neither escape the incidence of new external conditions (such as we know from actual observation do powerfully modify them), neither, if they could, should the progress of organization thereby cease—since the internal causes of change would still remain active and still continue to give rise to a "multiplication of effects," as Mr. Spencer has himself explained.

Thus, the existence of such lowest and simplest organisms as the microscope everywhere reveals at the present day, is quite irreconcilable with the position that life-evolution has not occurred since an epoch inconceivably remote in Time. Admit the present occurrence of Archebiosis and Heterogenesis, and both the existence and protean variability of the lowest organisms are at once readily explained. We may suppose them continually seething into existence afresh, endowed with enormous plasticity; so that new recruits are constantly appearing, ever ready to fill up the gaps which would otherwise be occasioned by promotion and death. The opposite doctrine, concerning such organisms as the structureless Amœba and the insignificant Mucor now daily appearing on decaying substances, seems opposed to all reason from the point of view of the Evolution Philosophy. As I have elsewhere asked:[1] "Would the Evolutionist really have us believe that such forms are direct continuations of an equally structureless matter which has existed for millions and millions of years without having undergone any differentiation? Would he have us believe that the simplest and most structureless Amœba of the present day can boast of a line of ancestors stretching back to such far remote periods that in comparison with them the primeval men were but as things of yesterday? The notion surely is preposterously absurd; or, if true, the fact would be sufficient to overthrow the very first principles of their own Evolution philosophy."—*Author's Advance Sheets.*

[1] "The Beginnings of Life," 1872, vol. i., p. 12.

ON THE ÆSTHETIC SENSE IN ANIMALS.

TRANSLATED FROM THE FRENCH OF LOUIS VIARDOT.

BY A. R. MACDONOUGH.

THE mind of animals is a very old subject of discussion. Descartes and his school regarded an animal as a mere piece of machinery, like a clock or a turnspit. For man alone they reserved intelligence, meaning by that, memory, feeling, will, and reason. The story of Malebranche is well known: As he was going into his convent at the Oratory with a friend, a little bitch ran up and fawned on him; he gave her a kick which sent the poor beast yelping off, and when his friend expressed surprise that so gentle, kindly, and Christian a person returned kicks for caresses, he exclaimed, "What! do you really suppose that that animal had any feeling?" Thus Malebranche not merely believed he had not wounded or grieved her; he even thought he had caused her no physical pain. This was denying clear proof, and pushing faith in his master's doctrine to absurdity.

On the other hand, Montaigne, Leibnitz, La Fontaine, Bayle, Condillac, Madame de Sévigné, agreeing with all antiquity, from Pythagoras to Galen, assert that animals have all the organs of sensation and of feeling; that they possess will, desires, memory, ideas, combinations of ideas, and even the power of performing some moral acts, such as entertaining attachment like that a dog feels for his master, or a hen for her chicks; or, like "that very just equality which they practise in dividing food or other good things among their young," as Montaigne says; and that therefore the intelligence of animals, if not equal to man's, is at least like it, and that the differences between the oyster anchored to its rock and the *homo sapiens* of Linnæus are merely differences between more and less, degrees of succession that make up what is called the scale of being. It is the latter opinion that has been declared triumphant by the researches of natural history and those of comparative anatomy alike. On this point science has reached certainty, and every one, reading the story of "the two Rats, the Fox and the Egg," says now with La Fontaine:

> "After that tale, where's the pretense
> That animals are lacking sense?"

But another dispute has just been opened on this question: "Have animals the sense of beauty, the æsthetic sense?" The famous Charles Darwin, and his numerous followers agreeing with him, displaying even greater generosity than Montaigne, Leibnitz, and La Fontaine, answer unhesitatingly in the affirmative. In their view, just as animals are endowed with intelligence as well as man, though in a lower degree, so in the same way and in the same proportion they

are endowed with the sense of beauty. They find the proof of this rather bold assertion, not in natural selection, which is a result of that struggle for life in which the weakest individuals among species, and the weakest species among genera, must disappear, but in sexual selection, which is a result of the struggle for reproduction, leading straight to the same consequences, namely, to the improvement of species and genera, which reaches, by slow elaboration through ages, even to their transformation. Among all animals, they say, among insects, fish, birds, mammals, the male chooses his female, and the female chooses her mate. If strength often determines the choice, so beauty often does too. The charm of graceful shapes, pleasing colors, fine notes, has great weight in settling the preference. Now, this charm which the male possesses habitually in a far higher degree than the female, he could have no occasion for whatever in the struggle for existence; he can benefit by it only in the struggle for reproduction. Hence all those displays of genuine coquetry which may easily be observed, in pairing-time, among all animals; hence those attractions prevailing through vigor of form, brilliant hues, and impassioned song. This general fact, well established under differences of appearance among all species and all genera, gives the Darwinian school ground for asserting that animals, having the perception of beauty, have consequently the æsthetic sense.

The opposing school, including of course all who prefer metaphysics to physiology, is by no means wanting in excellent answers. It says, by the pen of Charles Lévêque (in the *Revue des Deux Mondes* of September 1st), "the doctrine of Darwin rests, in its last analysis, on the capital fact that the animal, the male sometimes, the female sometimes, often both at once, is susceptible to the beauty of its kind. That the animal is struck with it, we admit; but does it feel really this beauty of color, form, and song, in so far as it is beauty, or is it not rather the fact that those brilliant tints, that vigor, that sweetness of voice, form for the animal an indication, very expressive, yet merely brute-like, of a physiological condition which its instinct expects, which itself stimulates and answers to?" And this question, which must involve in its solution that of the former one too, the anti-Darwinians answer in the affirmative, which is the negative of the first question. They point out that this process of choice, in which beauty wins the prize, takes place only at the season of pairing, and ceases through all the rest of the year; that if we concede to the animal a sense of the beautiful, within those limits, still the sense has but one special object, finds its range within the species merely, never reaches to a less concrete conception, does not widen, does not perfect itself by tradition and culture, remains unchangeably set on the same object, the same time, the same point; that admiration which grows from the expansion of this sense of beauty can only spring from very varied and delicate comparisons; in one word, that the animal, being

unable to attain general and abstract ideas, cannot rise to the æsthetic sense. To conclude: that sense is the exclusive endowment of man.

This is a concise statement—for neither our subject nor our powers allow us to take a side in this discussion—of the interesting controversy raised by Mr. Darwin's last book. We only say that, notwithstanding the deep respect and the frank support that we give to his general doctrine, we here adopt the opinion of his opponents. We, too, believe that the æsthetic sense, in the high and perfect acceptation of the phrase, belongs to man alone. But we must here suggest a correction of the highest importance, which will at once define our opinion, and lead us to a fundamental reflection upon the arts.

"Complete the experiment," M. Charles Lévêque says. "Place your animal before a work of art representing its male or its female with a precision that deceives the eye; some of these works that seemed to live existed in the studios of ancient painters; they are more frequent in modern museums and exhibition-rooms. It was said that mares would neigh when going before horses painted by Apelles. A dog would perhaps stop a moment in front of Oudry's hunting-pieces, if their frames were put on the floor, within reach of his look. He would come up, examine them, ask the canvas a single question with his infallible scent—and that would be all. And yet, what is there in the picture? There is exactly the element worthy of admiration, that is to say, the expression of life by means of the most attractive colors and the most perfect forms. What does the quadruped care for these as he looks at this wonder? It is not the expression of life in general that he wants; it is life itself, individual life, life which speaks to his senses, and to that of smell much more strongly than to his eyes and ears. He has no concern with the general, the ideal, the admirable; he understands nothing about them."

This is all strictly and absolutely true. We have never put much faith in the stories invented by the Greeks and collected by Pliny; we have never remarked, in our long experience as a sportsman, that the most intelligent of man's companions ever gave the least attention to any object represented by painting or sculpture, even to his master's portrait, or that he looked with any feeling of satisfaction at one of those charming landscapes set before us at every step by Nature, enchanting as their view is to us. That seems to us one settled fact. But is M. Lévêque quite certain that *all* men have any greater faculty for that notice and that knowledge which are wanting in the dog? Have savages got above the level of animals in this respect? A traveler, who has studied Australia thoroughly, relates that at a gathering of some native inhabitants of that country he brought out portraits of Queen Victoria and Prince Albert, to see what they would think of them. Almost all kept silence, seeing nothing in the pictures at all within their range, or that touched their

memory. But two of them, and the most intelligent ones among the tribe, such as can count as far as four, ventured on a remark. One said, "It is a boat"—the other, "It is a kangaroo."

All savages would answer in the same way, yet they are men. But, although they too love beauty after their fashion, though they have a strong liking for ornament, a great disposition for coquetry, savages do not go further than the special and individual object; they do not rise to a general, abstract idea; they know no more than the dog knows about seeing life in the representation of a living being. Therefore we need to correct the formula of Darwin's opponents, and may possibly thus succeed in bringing friends and enemies into agreement; their phrase must read, "The æsthetic sense belongs to civilized man alone.

In truth, it is not an innate faculty; it is a faculty acquired by tradition, by personal study, by the development of all the other faculties. The Australians must first learn to count as far as the number of fingers on the hand, and something more than that, before they can be able afterward to understand that pictures of a man and a woman, even if disfigured with a cap or crown, are neither boats nor kangaroos.

This assertion, that the æsthetic sense belongs only to civilized man, may be proved by both philosophic methods and by arguments which I take the liberty of stating concisely, as I have set them out at length in a treatise on the question "How should art be encouraged?" The subject is worth the risk of incurring ridicule for copying one's self. We may call it, if you choose, a second edition.

A priori, were we to assert that equality before the law means equality in intelligences, and that every man who has the right to be a citizen has the power to be an artist, we should commit a fundamental mistake. This would be confounding the feeling of the good in our nature with the feeling of the beautiful. The former is the instinctive knowledge of good and evil, of the just and the unjust; it is born with us, it is conscience itself, and, as such, it is necessary for all. The latter is a certain delicacy of sensation and of judgment which is formed very gradually in the course of life; it is called taste, and is useful only to a few. The feeling of the good, which marks the grand superiority of man over the animals, and forms the common basis of all societies, is an essential element in our nature, a gift we are forced to accept from the creative power. Without it, man would not be man. On the contrary, the feeling of the beautiful, which is less necessary, and may well be rare because it is superfluous, is an acquisition won by intelligence, slowly, painfully, uncertainly, and is often denied to the most honest efforts. One, like rank, costs nothing but the trouble of being born: the other demands, as all acquired knowledge does, a previous fitness, a kind of revelation, in which chance must often lend Nature its aid, besides time, reflection, mental labor in bodily leisure.

A posteriori: it is plain that a man's first movement, as regards the good, is almost always right; as regards the beautiful, almost always wrong. Listen to the crowd, judging by its moral estimate of an event that has taken place under its eyes, when no interest nor passion misleads it: what good sense, what fairness, what insight, what right intentions, what generous sympathies! Then hear it discoursing on the merit of works of art: what wretched taste, what glaring mistakes, what ridiculous enthusiasm, what sad and utter going astray! "The people," writes Diderot to Grimm, "looks at every thing, and gets at the meaning of nothing." But do you ask for still more decisive and clear practical proofs of the immense distance that separates knowledge of the good from that of the beautiful in the human mind? A petit jury, though it decides on the liberty, life, and honor of an accused person, is drawn merely by lot, because each citizen can judge as well as every other, upon evidence and discussion, of the truth and morality of an alleged fact. But do we choose the jury which has to award the prize of a competition from the same list and in the same way? No! in that case we must choose among the most skilled and the best qualified specialists.

But what need of demonstrating what his own experience tells every one? Among these skilled and special jurors where is the one who will not confess that he at first was, and long continued to be, the dupe of his ignorance? Which of them is not aware that taste for the arts, and, still more, taste in the arts, came to him only after a long time, after lucky and often casual experiences, after protracted studies, repeated comparisons, a constant exertion of the powers of seeing, understanding, feeling, judging? And who does not know, by having learned it in himself, that in the arts—except perhaps in music, which filters in unconsciously to those who hear it—emotions come in the train of reasonings, and that the first condition of positive admiration is knowledge? "I am fully persuaded," says Sir Joshua Reynolds, in one of his "Fifteen Discourses," "that the pleasure yielded us by the perfections of art is a taste which we acquire only by long study and with much labor."

Those who choose to attribute too liberally to all men the sense of the beautiful as well as that of the good, attempt to support their opinion by a fact. They cite the instance of Athens, where, they say, competition in the arts was open to all in the public arena, where the whole people formed the tribunal. The instance is misleading, and I take it the other way, to sustain my proposition. Without insisting on the special genius of ancient Greece among the other nations of the world, and that of the Athenian people among the other peoples of Greece, I will merely point out that this people of Athens, so small in its territory and population, so great in its deeds and renown, consisted of about forty thousand free citizens, served by four hundred thousand slaves. Now, the slaves, charged with all manual

tasks, and practising all the trades, relieved their masters from bodily labor, made them men of leisure, and consecrated them to the exclusive cultivation of the intellect, like the head of a body of which they were themselves the acting and subject limbs. That Athenian democracy, how jealous soever it might be of equality between citizens, was thus a real aristocracy; and we can very well understand how the decision on matters of art might be trusted to the multitude, when that multitude consisted entirely of men so enlightened, by education and experience, that all public functions and all magistracies might be distributed among them by lot, without any great danger to the state. The empire of the arts, though it refuses to accept any boundaries as haughtily as that of science does, though speaking as well a universal language it spreads over the whole world, can be ruled only by a strict oligarchy. Indeed, as has been justly said, good taste is the quintessence of good sense. Therefore, whatever may be our devotion to equality before the law, we can never admit equality before genius, or even before that talent which the cultivation of art requires.

Among mankind art has been, and always will be, the exclusive share of a small minority; in fact, a very choice and very limited aristocracy. It is assuredly not that of birth, for there is nothing more personal than genius or talent. It is aristocracy in its true and genuine sense—the privilege of the best. Art belongs only to certain exceptional natures, very rare because they are highly endowed, whose possessors must combine with the choicest moral faculties, imagination with judgment, feeling with taste, other precious physical faculties, clearness of view, and precision of touch. All men may be artisans; only the best, the *aristoi*, can be artists.

To conclude, and still taking the phrase "æsthetic sense" in its highest and perfect meaning, we first deny it to animals; and next, holding this delicate sense to be one of the noblest attributes of mankind, we restrict it to civilized man; then last, even among nations whom continued and general cultivation places in the front rank of humanity, we allow this æsthetic sense only to some groups of select men, on whom the nature of their minds and their taste formed by long study confers this rare and precious privilege. Has not Stendhal declared that all literary reputations are made by a choice circle of five hundred readers? And it is a certain truth that the number of bachelors of arts is still smaller than the number of bachelors of letters.

However, not to overstep the very modest part suited to mere writers and professional critics, let us hasten to add that, if in art the public voice is that of a very small number, but acute, practised, and disinterestedly enthusiastic; if this voice alone decrees to the living the rewards of celebrity, to the dead the immortality of fame; if, moreover, this choice circle of connoisseurs has the sole right of

criticism, it by no means follows thence that every one of its members has the gift of infallibility. Far from that; it is like that aristocratic democracy of Athens, in which each citizen had his personal vote only, and could prevail only on condition of convincing. As in the domain of the good there is but one authority—conscience, so there is but one authority in the domain of the beautiful—taste. Only, conscience speaks the same language to all the men of one community; while taste, on the contrary, even acquired and formed taste, is as manifold as temperaments, ideas, and passions are. It varies from country to country in every age, and from age to age in every country. Still further, it varies between man and man, and in each man, at different periods of life. The bear in the fable very sensibly says:

> "Who tells you this shape's awkward, that one fine?
> Has yours the right to judge or censure mine?"

Therefore it is in vain, as if in strict pursuance of a duty, to read all books, listen to all counsels, ask advice from people supposed to be cleverer than one's self, and prop up one's judgment by more sure and authoritative judgments. In the criticism of art, where positive canons are wanting, no one is suffered to deem himself an authority; no one is any thing more than an opinion.—*Gazette des Beaux Arts.*

A YEAR OF GEOGRAPHICAL WORK.

AT the annual meeting of the American Geographical Society, held on the 13th of January, 1874, the address was delivered by the President of the Society, Chief-Justice Daly, who gave to a large and intelligent audience an admirable digest of geographical work and progress during the past year. In his elaborate and most instructive remarks, after dilating on the object and use of geographical societies, and making special allusion to the great results of what might be called the geographical society formed by Prince Henry and his associates upon the promontory of Sagres, in Southern Portugal, viz., the discovery of the passage to the East Indies by the Cape of Good Hope, the president went on to state that there is yet one-seventeenth part of the globe of which we know nothing, except by conjecture, especially in the north and south polar regions, in Central Africa, in the interior or northern parts of Australia, and some of the great East Indian islands, e. g., Borneo and New Guinea. Many regions in South America, in Asia, and even a considerable portion of our own Western country, are not yet fully explored. These may yet be outlets for the surplus population of longer-settled and overstocked countries. Geographical research aids the progress of physical geography, especially our knowl-

edge of the wind and ocean currents of the globe, and the mysterious laws of terrestrial magnetism.

It was with the object of stimulating geographical inquiry that the first geographical society was formed in Great Britain forty-three years ago. There are now thirty-three similar societies over the globe, viz., in England, France, Holland, Belgium, Italy, Spain, Germany, Hungary, Russia, India, United States, Mexico, Brazil, and Buenos Ayres. These more or less influence public opinion, governments, and wealthy individuals, willing to aid exploration, and the expeditions of the year have been unusually numerous. Never has there been such zeal as during the last quarter of a century, from their associated efforts. It is only very large and wealthy societies, like those of London and St. Petersburg, however, which can engage in distant and expensive explorations, but all can aid in pointing out suitable fields for exploration, and impressing on the age the necessity and value of it.

In reviewing the geographical work of the world during the year, President Daly commenced with the Coast Survey, which Humboldt in 1851 said would hereafter be our great scientific monument. The valuable practical land operations of the Engineer Corps, U. S. A.; the labors of the Hydrographic Office at Washington; the United States Geological and Geographical Survey of the Western Territories; the Yellowstone Expedition under General Stanley, and the less military one under Captain Jones, with their valuable scientific results—were in turn treated in detail; after which the president reviewed Lieutenant Wheeler's exploration of the White Mountains of Arizona. The Yale College Expedition, instituted by Prof. Marsh, to explore between Salt Lake City and the Colorado River, gave us five tons of fossil and other collections. The explorers received great attention from the Mormons, owing to the discovery of fossil remains of various species of horses. Certain events are related in the Book of Mormon as occurring in the prehistoric period of America, in which horses are mentioned. According to the Spanish historians, horses did not exist in America till introduced by their countrymen, and this statement has been taken as evidence that the Book of Mormon is a fabrication. The Mormons, therefore, regard Prof. Marsh's discovery of fossil horses in Oregon as a proof of the inspiration of the Book of Mormon. The expedition and researches of Dall, in the Aleutian Islands and North Pacific, are also interesting.

The archæological discoveries of the year were next briefly reviewed, and more fully the voyage of the Polaris by way of Smith's Sound to within little more than 400 miles of the north pole. A Swedish expedition was sent out, under Prof. Nordenskiöld, to Parry Island; a Norwegian to the east of Spitzbergen, and an Austrian to the east of Nova Zembla. The practicability of a ship-canal across the Isthmus of Darien, by way of the Atrato, has been tested by an expedition under Commander Selfridge, and, by Commander Lull, of an-

other route from Greytown, by San Juan River and Lake. Prof. James Orton, of Vassar College, just returned from South America, has added a great deal of valuable knowledge of the geography and zoology of Amazonia. Hurlbut has crossed the Cordilleras from Lima to Lake Titicaca, while Captain Musters has journeyed through Patagonia. A narrative of the valuable explorations of Señor Raimondi in the little-known portions of Peru, to the west of the Andes, is to be published by the Peruvian Government.

The main geographical work of Europe has been the carrying out of those valuable national topographical surveys on which, as the recent Franco-Prussian War shows, the fate of nations may depend. The agreement of the Meteorological Congress, held at Vienna, was unanimous as to the great importance of synchronous meteorological observations all over the world. The scientific results of the Challenger's voyage, and of Prof. Mohn's deep-sea investigations to the north of Europe, were next alluded to.

Asia has been the scene of considerable activity in geographical exploration. Elias has traveled, almost alone, from Peking to St. Petersburg, across Chinese Tartary. The Russian capture of Khiva will produce important geographical and political results. Among the most important of recent geographical expeditions is that of Mr. Jacob Halevy, through Yemen, in the Arabian Peninsula.

Both the English and the American societies have been surveying and exploring in Palestine, the labors of the former being nearly ended, those of the latter only entered upon. The English expedition, under Captain Warren, employed chiefly in exploring Jerusalem, with branch expeditions to the plain of Philistia, and the comparatively unknown regions east of the Jordan and Mount Lebanon, has settled disputed questions, determined astronomically the position of many places, aided in elucidating ancient history, and also added much to our knowledge of local topography. The British Ordnance Survey of the Peninsula of Sinai has, among other things, remarkably corroborated the truthfulness and accuracy of Biblical history, as did also the examination of the desert of the Exodus by Prof. Palmer and Mr. Drake. By arrangement with the English society, the country lying to the east of the Jordan and Dead Sea has been undertaken by the American Palestine Exploring Society, under Lieutenant Steever, U. S. A. This embraces the lands of Moab and Edom, where the celebrated Moabite Stone was found, which illustrated so fully the origin and history of our alphabet, and the art of writing. The surveys for the various railroad routes between London and India were then briefly alluded to.

The geographical intelligence from Africa is varied, but not so interesting as during the previous year. It embraces Nachtigall's journey in the Wadai country; that of Rohlfs from North Africa to Lagos; the Livingstone relief expedition of Cameron; Sir S. Baker's efforts to suppress the slave-trade in the Upper Nile region; Miani's travels

along the White Nile to the Monbutta country, where he lost his life. A difficult journey was made by Prof. Blyden to Falaba, a little-known country to the northeast of Sierra Leone. Marche and Compeigne are now penetrating Equatorial Africa in the vicinity of the Gaboon. Besides these, it should be remembered that hundreds of residents, living on the coast or having trading outposts in the interior, annually contribute a rich fund to geographical knowledge by correspondence or publications. Among these are Bushnell of the Gaboon, who supplies valuable letters, Hansell of Khartoum, and Munzinger Bey, one of the ablest geographers and most experienced travelers, and corresponding member at Masswah of the American Geographical Society. The effect of the Anglo-Ashantee War on our geographical knowledge cannot yet be fairly estimated.

In Australasia the eastern shore of New Guinea has been explored by Captain Moresby, of the British Navy, in H. M. S. Basilisk, who dispels many false impressions prevalent regarding that hitherto little-known but highly-interesting island and its inhabitants. The island has been crossed from Geelvinks Bay to McClure Gulf by Dr. Meyer, who, like Moresby, but unlike Beccari, who has been exploring there, gives a favorable account of the island and its people. Formosa has been traversed from north to south by Thompson and Maxwell, who found coal. It would be premature to speak of the geographical results of the Dutch Acheen expedition.

Mr. Ernest Giles and Baron von Müller have been exploring Central Australia, and gathering much accurate geographical information. The telegraphic event of the year has been the construction of a line across Australia, from Adelaide in the south to Port Darwin on the north coast, a distance of 2,012 miles, which gives a continuous line from Adelaide to Gibraltar, a distance of 12,462 miles, of which 9,146 are submarine, by which Australia has three weeks' earlier news than by the mail-steamers. The last geographical intelligence from Australia is the discovery of thousands of acres of the richest sugar-growing land near Cardwell, in Northern Queensland, by a government exploring expedition. Judge Daly's instructive address, of which we have only given an outline, is well worth careful perusal, nor can its fresh and valuable details fail to awaken a fresh and wider interest in geographical science, or to give a renewed impetus to geographical discovery, while showing that America and Americans are not behind the age in geographical zeal and enterprise.

In an appendix we also find some valuable information regarding the United States Geological Survey of the Territories (Montana, Idaho, Wyoming, and Utah), in 1872, extracted from the report of the Government geologist, J. V. Hayden.

SKETCH OF PROFESSOR HUXLEY.[1]

By ERNST HAECKEL,
OF THE UNIVERSITY OF JENA.

THOMAS HENRY HUXLEY was born at Ealing, on May 4, 1825. With the exception of two and a half years spent at the semi-public school at Ealing, of which his father was one of the masters, his education was carried on at home, and in his later boyhood was chiefly the result of his own efforts. In 1842 he entered the medical school attached to Charing Cross Hospital, where, at that time, Mr. Wharton Jones, distinguished alike as a physiologist and oculist, was lecturing on physiology. In 1845 Mr. Huxley passed the first M. B. examination at the University of London, and was placed second in the list of honors for Anatomy and Physiology, the first place being given to Dr. Ransome, now of Nottingham. After some experience of the duties of his profession among the poor of London, in 1846 he joined the medical service of the Royal Navy, and proceeded to Haslar Hospital. Thence he was selected, through the influence of the distinguished arctic traveler and naturalist, Sir John Richardson, to occupy the post of assistant-surgeon to H. M. S. Rattlesnake, then about to proceed on a surveying voyage in the Southern Seas. The Rattlesnake, commanded by Captain Owen Stanley, with Mr. MacGillivray as naturalist, sailed from England in the winter of 1846. She surveyed the Inner Route between the Barrier Reef and the East Coast of Australia and New Guinea, and, after making a voyage of circumnavigation, returned to England in November, 1850. During this period Mr. Huxley investigated, with a success known to all naturalists, the fauna of the seas which he traversed, and sent home several communications, some of which were published in the "Philosophical Transactions" of the Royal Society. The first which so appeared, presented by the late Bishop of Norwich, and read June 21, 1849, bears the title "On the Anatomy and Affinities of the Family of the Medusæ." This was, however, not Mr. Huxley's first scientific effort. While yet a student at Charing Cross Hospital, he had sent a brief notice to the *Medical Times and Gazette*, of that layer in the root-sheath of hair which has since borne the name of Huxley's Layer. Shortly after his return he was (June, 1851) elected a Fellow of the Royal Society.

In 1853 Mr. Huxley, after vainly endeavoring to obtain the publication by the Government of a part of the work done during his voyage, left the naval service, and in 1854, on the removal of Edward Forbes from the Government School of Mines to the chair of Natural

[1] From *Nature*. The first part of this sketch has been supplied by its editor.

History at Edinburgh, succeeded his distinguished friend as Professor of Natural History in that institution, a post which he has continued to hold up to the present day. Since that time Mr. Huxley has lived in London a life of continued and brilliant labor. From 1863 to 1869 he held the post of Hunterian Professor at the Royal College of Surgeons. He was twice chosen Fullerian Professor of Physiology at the Royal Institution of Great Britain. In 1869 and 1870 he was President of the Geological Society, having previously served as secretary. During the same period he was President of the Ethnological Society. In 1870 he filled the office of President of the British Association for the Advancement of Science, and in 1872 was elected secretary to the Royal Society. He has been elected a corresponding member of the Academies of Berlin, Munich, St. Petersburg, and of other foreign scientific societies, has received honorary degrees from the Universities of Breslau and Edinburgh, and last year was presented with the Order of the Northern Star by the King of Sweden. Since 1870 he has been one of the members of the Royal Commission on Scientific Instruction and the Advancement of Science. From 1870 to 1872 he served on the London School Board as one of the members for Marylebone, and during that time was chairman of the Education Committee which arranged the scheme of education adopted in the Board Schools. In 1872 he was elected Lord Rector of the University of Aberdeen.

In this skeleton narrative of the career of this distinguished naturalist we have purposely omitted any list or any critical estimate of his writings; but we have great pleasure in laying before our readers, as a token of what is thought of him by those who are laboring in the same field of science, the following communication from one who ranks, in his own country as well as among ourselves, as one of the very first of German naturalists.

The more general, year by year, the interest taken by all educated people in the progress of natural science, and the wider, day by day, the field of science, the more difficult is it for the man of science himself to keep pace with all the advances made—the smaller becomes the number of those who are able to take a bird's-eye view of the whole field of science, and in whose minds the higher interest of the philosophical importance of the whole is not lost amid a crowd of fascinating particulars. Indeed, if at the present moment we run over the names distinguished in the several sciences into which Natural Knowledge may be divided—in Physics, in Chemistry, in Botany, in Zoology—we find but few investigators who can be said to have thoroughly mastered the whole range of any one of them. Among these few we must place Thomas Henry Huxley, the distinguished British investigator, who at the present time justly ranks as the first zoologist

among his countrymen. When we say the first zoologist, we give the widest and fullest signification to the word "zoology" which the latest developments of this science demand. Zoology is, in this sense, the entire biology of animals; and we accordingly consider as essential parts of it the whole field of Animal Morphology and Physiology, including not only Comparative Anatomy and Embryology, but also Systematic Zoology, Paleontology, and Zoological Philosophy. We look upon it as a special merit in Prof. Huxley that he has a thoroughly broad conception of the science in which he labors, and that, with a most careful empirical acquaintance with individual phenomena, he combines a clear philosophical appreciation of general relations.

When we consider the long series of distinguished memoirs with which, during the last quarter of a century, Prof. Huxley has enriched zoological literature, we find that in each of the larger divisions of the animal kingdom we are indebted to him for important discoveries.

From the lowest animals, he has gradually extended his investigations up to the highest, and even to man. His earlier labors were, for the most part, occupied with the lower marine animals, especially with the pelagic organisms swimming at the surface of the open sea. He availed himself of an excellent opportunity for the study of these, when on board H. M. S. Rattlesnake on a voyage of circumnavigation, which took him to many most interesting parts of tropical oceans little investigated, previously, by the zoologist; especially the coasts of Australia. Here he was able to observe, in their living state, a host of lower pelagic animals, some of which had not at all been studied, others but imperfectly. In the Protozoa, he was the first to lead us to satisfactory conclusions concerning the nature of the puzzling Thalassicollidæ and Sphærozoida. Our knowledge of Zoophytes has been greatly extended by his splendid work on "Oceanic Hydrozoa," in which, chiefly, the remarkable Siphonophora, with their largely-developed polymorphism and the instructive division of labor in their individual organs, are described with very great accuracy.

Already in his first work "On the Anatomy and Affinities of the Medusæ," 1849, he directed attention to the very important point, that the body of these animals is constructed of two cell-layers—of the Ectoderm and the Endoderm—and that these, physiologically and morphologically, may be compared to the two germinal layers of the higher animals. He has made us better acquainted with several interesting members of the class Vermes, Sagitta, Lacinularia, some lower Annulosa, etc. He was the first to point out the affinities of Echinodermata with Vermes. In opposition to the old view, that the Echinodermata belong to the Radiata, and, on account of their radial type, are to be classed with corals, medusæ, etc., Huxley showed that the whole organization of the former is essentially different from that of the latter, and that the Echinoderms are more nearly related, morpho-

logically, to worms. Further he has essentially enlarged our knowledge of the important group of Tunicata by his researches on the Ascidians, Appendicularia, Pyrosoma, Doliolum, Salpa, etc.

Many important advances in the morphology of the Mollusca and Arthropoda are also due to him. Thus, e. g., he has greatly elucidated the controverted subject of the homology of regions of the body in the various classes of Mollusca. He has considered the generation of vine-fretters from quite a new point of view, based on his "genealogical conception of animal Individuality." But it is the comparative anatomy and classification of the Vertebrata which, during the last ten years, he has especially studied and advanced. His excellent "Lectures on the Elements of Comparative Anatomy" afford abundant proof of this, to say nothing of his numerous important monographs, especially those on living and extinct fish, amphibians, reptiles, birds, and mammals.

Huxley's works on the comparative anatomy of the Vertebrata are the only ones which can be compared with the otherwise incomparable investigations of Carl Gegenbaur. These two inquirers exhibit, particularly in their peculiar scientific development, many points of relationship. They both belong to that small circle of morphologists which is marked by the names of Caspar Friedrich Wolff, George Cuvier, Wolfgang Goethe, Johannes Müller, and Carl Ernst von Baer.

More important than any of the individual discoveries which are contained in Huxley's numerous less and greater researches on the most widely different animals, are the profound and truly philosophical conceptions which have guided him in his inquiries, have always enabled him to distinguish the essential from the unessential, and to value special empirical facts chiefly as a means of arriving at general ideas. Those views of the two germinal layers of animals which were published as early as 1849 belong to the most important generalizations of comparative anatomy; they already contain in germ the idea of the "perfect homology of the two primary germinal layers through the whole series of animals (except protozoa)," which first found its complete expression, a short time since, in the "Gastræa theory;" also his researches on animal individuality, his treatment of the celebrated vertebral theory of the skull, in which he first opened out the right track, following which Carl Gegenbaur has solved in so brilliant a manner this important problem, and, above all, his exposition of the Theory of Descent and its consequences belong to this class. After Charles Darwin had, in 1859, reconstructed this most important biological theory, and, by his epoch-making theory of Natural Selection, placed it on an entirely new foundation, Huxley was the first who extended it to man; and, in 1863, in his celebrated three lectures on "Man's Place in Nature," admirably worked out its most important developments. With luminous clearness and convincing certainty, he has

here established the fundamental law that, in every respect, the anatomical differences between man and the highest apes are of less value than those between the highest and the lowest apes. Especially weighty is the evidence adduced, for this law, in the most important of all organs—the brain; and by this the objections of Prof. Richard Owen are, at the same time, thoroughly refuted. Not only has the Evolution Theory received from Prof. Huxley a complete demonstration of its immense importance, not only has it been largely advanced by his valuable comparative researches, but its spread among the general public has been largely due to his well-known popular writings. In these he has accomplished the difficult task of rendering most fully and clearly intelligible, to an educated public of very various ranks, the highest problems of philosophical biology. From the lowest to the highest organisms, from Bathybius up to man, he has elucidated the connecting law of development.

In these several ways he has, in the struggle for truth, rendered Science a service which must ever rank as one of the highest of his many and great scientific merits.

No statement of the character and work of Prof. Huxley would be complete that did not recognize his remarkable attainments as a writer. All who have read the masterly papers contained in "Lay Sermons," or the "Critiques and Addresses," will acknowledge his fine and vigorous command of English, and the literary richness of his style. He has a keen enjoyment of literary excellence, and "keeps up" with poetry, fiction, and the progress of critical thought, notwithstanding his indefatigable scientific investigations. Owing to these traits, Prof. Huxley has a high reputation as a popular scientific teacher; and even his "Lectures to Working-men" are models of what such discourses should be—clear, simple, and attractive, yet carefully accurate and strictly scientific. As a public speaker he is quiet, deliberate, fluent, and, we might almost say, colloquial; while socially he is genial, witty, and brilliant. He is, moreover, a man of enlarged sympathies, in this respect contrasting markedly with many scientific men, who are swallowed up in their specialties, and never give a thought to any thing beyond them. Prof. Huxley has, however, overworked himself, and damaged his health. We hope he will regain his power, and be able to give this country a season of lecturing, as he has long hoped to do. He is perhaps the only scientific man in England who could revive for us the pleasant experience we had with Prof. Tyndall last year.

CORRESPONDENCE.

NOTE ON THE BREEDING HABITS OF THE MUD-MINNOW.

OUR very common "mud-minnow" (*Melanura limi*, Agassiz—*Silliman's American Journal of Science*, 1853, vol. xvi., p. 135), which is found over a wide extent of territory in America, and which, according to Dr. Albert Günther ("Catalogue of Fishes," in the British Museum, vol. vi., p. 231), is generically the same as the *Umbra crameri* of Europe, presents some features in its breeding habits which we have thought of particular interest, and would be greatly pleased to know if the European *Umbra crameri*, which Dr. Günther states inhabits the "stagnant waters of Austria and Hungary—neighborhood of Odessa," has identical habits; or, if the difference of climate, and character of the surroundings generally, have caused a more or less noticeable variation in its habits, especially during the spawning-season. We have not access to any work, on the fishes of Central Europe, that gives any details of their habits.

As we have already described it (*American Naturalist*, vol. iv., pp. 107, 388, Fig. 86), this little umbra is, "pure and simple," a mud-loving fish, and more strictly so than any other, unless we may except the eel (*Anguilla acutirostris*). During the present winter we have had unusually favorable opportunities for studying the fish during this part of the year. In December, while the weather was cool rather than cold, with but little ice, we found that hundreds of these fish were being thrown out with the mud then being scooped from the ditches of the tract of meadow on the writer's farm. On learning this, we had the mud carefully taken out by shovelfuls and examined, to learn the exact condition and position of these fish. They were, when taken from the mud, motionless, stiff, and apparently frozen; they were not brittle, and an attempt to bend or break them resulted in a very prompt but partial restoration of vitality (or consciousness?). Specimens thus roughly handled were permanently injured by being bent, even if not in excess of a degree of curvature that they can and do readily assume when in their normal condition. On placing specimens freed from mud in water of a temperature of 60° Fahr., which is pretty nearly or quite that of the ditch-water in summer, they only fully revived after lying on their sides, at the bottom of the vessel, for from twenty-five to forty minutes, and seemed to be injured permanently by the sudden change; but, if placed, with the mud still adhering to them, in water at a temperature of 40° Fahr., which became gradually warmer, by the vessel containing the fish being removed to a warm room, the minnows would become wholly themselves again, in from ten to fifteen minutes, and swim off in full vigor, as the mud slowly loosened from them and settled to the bottom of the vessel. As taken from the bottom of the ditch, the mud in which these minnows were hibernating was of about the consistency of cheese. As far as we were able to determine, these fish had burrowed tail-foremost, to a depth of from four to nine inches, and, in every instance, we believe the tail was deeper than the head, the position varying from almost horizontal to nearly or quite perpendicular.

Pursuing the investigation somewhat further, we found that, where these fishes had gone into winter-quarters in deep water, i. e., from three to five feet deep, the hibernating slumber was not as profound; and, when they were placed in clear water, at a temperature of 46° Fahr., they almost immediately swam about; slowly at first, but with steadily-increasing activity, and, in from three to five minutes, were in full possession of all their powers, and assumed the statue-like positions common to them, when seen in summer, when, for many minutes together, they will remain immovable, and only move when the near approach of an insect larva offers them a sure chance for a meal, or portion of one. It should be here mentioned that the water in the ditches from which we first gathered specimens varied from nine to fifteen inches in depth, and was coated with ice one inch thick.

During the past month (February), the weather being most of the time mild and spring-like—the smaller frogs singing throughout the day—we watched for the first appearance of these mud-minnows, and saw them in scanty numbers, first, on Sunday, the 15th. A week later (Monday, 23d), we found but few specimens in the muddy ditches, but a vast number of females, with distended abdomens, heavy with orange-colored masses of ripe (?) ova, in the swift, clear, ice-cold waters of the hill-side brooks.

On the 25th there was a violent snow-storm, with cold northeast winds, but this did not deter the "onward" movement of the minnows. Of the specimens taken from the rivulets, at this time, none were males, and it seems probable, although we could not positively ascertain the truth, that the male fish follow the females, and either seek out the deposited ova and fertilize it (does this ever happen?), or that the females wait until the arrival of the males before depositing their eggs.

We would refer, in conclusion, to one feature of their habits again. These fish, at the commencement of winter, by burrowing deeply in the mud of the waters they frequent, avoid the decided lowering of the temperature, which they, at this season, seem unable to withstand; but, at the approach of spring, they arrive, synchronously with the maturing of the ova in the females, and milt in the males, and, after thus recovering their wonted activity—say in February—no amount of severe weather deters them from seeking out exceptionally cold waters for their spawning-beds. This was shown by the late snow-storm above referred to, after which the female minnows were still found passing up the brooks, forcing their way up miniature cascades, with all the agility of a salmon, leaping from eddy to eddy, seeking out the most distant points from their muddy summer haunts that they could reach; and here, where but little water flowed, and with the dry grass and twigs projecting from it, thickly coated with crystal ice and glistening frost, we found the plainly-colored, diminutive mud-minnows hidden among the pebbles and sandy ridges of the brook-bed.

CHARLES C. ABBOTT, M. D.

TRENTON, N. J., *March* 2, 1874.

ANIMAL MIGRATIONS.

To the Editor of the Popular Science Monthly:

I BELIEVE that grasshoppers (locusts) migrate solely on account of an enemy—a dipterous insect much resembling the house-fly, but larger, quicker, and grayish in color, owing to the white hairs at the edges of the articulations. This insect deposits its eggs in the upper part of the locust's abdomen, when the latter is resting on the ground, as it cannot do so when flying. Its favorite moment of attack is just as the locust alights from a flight or a hop. In a few days the larva or maggot is about a quarter of an inch in length. Soon the locust dies, when the larva eats its way out and burrows in the ground for transformation. Sometimes four of these larvæ will be found in one locust. I first noticed this in the summer of 1871. In 1872, when a flight of locusts began to arrive, the fly destroyed nearly all that came during the first two weeks, or until cool nights seemed to stop its multiplication. In 1873 I had an unusually fine opportunity to observe the locusts, as they hatched in incredible numbers upon my farm, and devoured my crops. During the whole summer the fly left the locusts no quiet, but drove them to most desperate straits to avoid the attacks; so that, as soon as the locusts acquired wings, they flew away—that is, what were *left* of them, for I estimate that not one in fifty escaped death. In places where the irrigating ditches prevented them from crawling forward, they were piled two and three inches deep. The ground during the cool of the day would be dotted with white maggots crawling off to find burrows. The locusts did not leave on account of famine, for there were ample fields of grain and other crops untouched; and they would sometimes abandon a field when only slightly eaten. Besides, I have seen the swarm floating all day in the air when still, and constantly alighting and arising, as hunger impelled from above, or the fly from below. I do not find this fly mentioned in Tenney's work on "Entomology." If comparatively new, there is hope that it will work the destruction of the locusts. I also believe the latter can be readily destroyed by the combined efforts of man, as they hatch in exceedingly small areas.

The prairie-dog (*Cynomes ludovicianus*) is migratory, although it moves slowly, accomplishing hardly more than half a mile a year. Apparently, their object is to obtain fresh food, for they eat root and branch as they go. The leaders are, invariably, the young, who are constantly driven out by their more mature and powerful brethren. Their vacated holes are occupied by owls and rattle-snakes, but whether these prove enemies or not I do not know.

I strongly suspect that the cause of migration in the lemmings is the parasites which infest their bodies. These, after a few years, increase to such numbers as to be unendurable; then the lemmings set out and are never *known* to return until they have overcome their enemies in the flood.

S. E. WILBER.

GREELEY, COLORADO, *Feb.* 28, 1874.

MR. SPENCER AND THE WOMEN.

SIR: Two papers have already appeared in your columns relating to Mr. Herbert Spencer's "Study of Sociology:"—a direct review of the work, January 10th, to which Viscount Amberley has given the credit of fairly appending to it his own name, thus placing his comments on the author's view of women on the true class-footing of their being the judgment of a man; and a letter, December 20th, confined to this point, to which, through its being signed only with the initial "L.," class-weight of this sort is entirely wanting, notwithstanding the actual force of its remarks—thus forming, as I wish to argue, a notable instance of the undesirableness of that practice of signing by mere initials which is contended for in another article of the first-mentioned number, on the ground of its being a protection to the modest, retiring, sensitive nature of some writers who yet feel that they have something to say which would be well said. My object, then, is now the twofold one, of on the one hand repeating (with some difference) the main arguments of "L.," under the avowed character of a woman; and on the other of pressing upon my fellow-women the present necessity, as especially called forth by Mr. Spencer's recent work, of women *not* indulging on this occasion in the moral timidity which the hiding of their real names is the effect of. It is the peculiarity of the case that, as all writers have hitherto been taken for granted to be men, there has sprung a natural desire among actual women-writers to play a trick on the public, which has thence caused them as much as possible to force the matter of their own thoughts into the mould of those of men. And although, perhaps, there may be little harm in this where it is fiction alone that is concerned, I contend that it is really a deep injury in relation to those practical questions with which specially all the literature of journals must be occupied.

I share strongly with "L." the disappointment which he or she expresses on the turn which to me also appears indicated in Mr. Spencer's design *against* the present desire arisen in women to take their part in the social regulating of their country. I mean, chiefly, as to those appended statements of his, cast as if casually into the foot-notes at the end of his volume, which, however, contain in this peculiar instance what must be taken by his readers as a sort of *a priori* basis to his whole intended reasoning on the subject to come; the whole statements, crowded into almost a single page, regard matters on which it is the very claim of women that no settled opinion is yet possible. Mr. Spencer signifies that whatever fruits of the higher kind of intellect women possibly may produce are, nevertheless, by a certain degree of "normal limitation," to be accounted of as mere mental monstrosities—mere aberrations from the true course of development which is the only profitable course. He obviously thinks it nothing against such course that some of the number of *men* should exclude themselves from the ordinary duties of domestic and social life, in order that, by strained efforts at intellectual illumination, they may guide those self-efforts of commoner men, which, in the case of men, he asserts are the only true means of real culture; but with *women* he implies that all such seclusion can inevitably produce nothing of any value so long as *men* are at hand to afford the required lights. Nothing but an absolute dearth of men present to do that for women which normally they cannot do for themselves — the case referred to being

specially that of ascertaining their own social status—can justify the alleged wasting of their real powers! Surely this is a reversal of his plan for men, threatening a philosophic tyranny in his future scheme over the true instincts of women, which the latter cannot possibly feel to be justice to them.

Most needfully, then, in the face of such threatened injury on the part of a writer who is daily becoming more and more of deserved weight in social topics, must women look to one another; that is, for the openly-expressed class-feeling which manifestly is the thing that is now called for. The best thing that has been said for us by Mr. Mill, and that for which I think, for one, we owe him a debt of gratitude never to be extinguished, is that, after all, *women must speak for themselves.* Unless they will do so, this most generous of our advocates has said, it must remain "impossible that any man, or all men taken together, should have knowledge which can qualify them to lay down the law to women as to what is, or is not, their vocation" ("Subjection of Women," p. 48). Let me, however, add, on the other side, that in my own view this demand of self-expression from women by no means includes any equal need of immediate political *action.* Until the subject has been well *thought* out between men and women, with much more of careful study than is compatible with popular agitation, I am convinced that any too eager pressing forward toward practical arrangement of it must be dangerously premature. And for this end I believe truly that we need, not only all the instruction that Mr. Spencer can give us, both philosophic and scientific, but all the strenuous mental effort on the part of at least those who must take lead among us, which he seems to condemn. I recognize fully that we can in no way do better than to take him as our teacher—however little he may perhaps himself approve of this—provided always that in learning from him we remain true to ourselves.

I am, etc., SARA S. HENNELL.

COVENTRY, *January* 20, 1874.

—*Examiner.*

EDITOR'S TABLE.

THE WORK AND INFLUENCE OF THE MONTHLY.

THE present number closes the second year and the fourth volume of THE POPULAR SCIENCE MONTHLY. That it met a demand is shown by the fact that it has been better sustained than any other scientific magazine of its class that has been started in any country. That it has fulfilled its early promise in the estimation of the public, is shown also by the fact that it has been increasingly commended with each succeeding issue. We wish to make it still better, but our power to do so will depend upon the liberality of its patronage; and we therefore solicit all who would increase its strength and extend its usefulness, to do what they can to make it more widely known in their respective circles of inquiring and intelligent readers. The MONTHLY is as yet known to but very few of those who would appreciate and prize it, and our friends can do much, as many of them have already done, by lending their copies to thoughtful neighbors, and inducing them to form clubs.

In regard to the character of THE POPULAR SCIENCE MONTHLY, we have preferred to let it speak for itself, and have made no parade of the numerous and flattering commendations of it which we have received from eminent sources. But there come a few words regarding the importance of our work from a distant country, which we may be excused for giving to our readers.

From a letter of Mr. Bancroft, American minister at the court of Berlin, to the publishers in New York, we select the following passage: "I receive from time to time your POPULAR

SCIENCE MONTHLY, which I think excellent in itself and perfectly adapted to its purpose of diffusing knowledge and a right way of thinking more widely among the people. I have done what I could to spread the knowledge of the periodical, and it is here very highly esteemed. Prof. Helmholtz and Prof. Dubois-Reymond have both spoken to me their opinions very much in its favor, and higher authority could not be found. I should not do justice to my own opinions if I did not add how well I think you deserve of the country for the persistent and judicious manner in which you employ your great influence through your business to spread through the country the important works of science as fast as they appear. In this way you give very material aid toward educating the coming generation to the love of truth and a knowledge of the world in which they live."

In the same letter Mr. Bancroft adds: "I send you to-day a copy of a masterly address of Prof. Dubois-Reymond, who, you know, stands among the highest in his branch of science: I hope you will have it translated and published in THE POPULAR SCIENCE MONTHLY. No essay of the kind since I have been in Germany has attracted so much attention, and, as you see, it has already arrived at its third edition." The address here spoken of is on "The Limits of our Knowledge of Nature." It is certainly a masterly discussion, and will appear in our next issue.

THE HIGHER EDUCATION OF WOMAN.

OF the great movement of modern culture, one of the most important phases is that now recognized as the "higher education of woman." That woman requires a better education than she has hitherto had, and that it should also be of a higher grade, are undeniable, although the practical questions that arise in the attempt to define and attain it are serious and formidable. The prevalent short-cut solution of the problem—women crave a higher education, therefore open to them the higher institutions—is as far as possible from being an adequate or satisfactory disposition of the case.

It is a constant complaint among the leaders of the woman's movement, that, in consequence of the long subjection of the sex to the domination of men, women have not been allowed or incited to think for themselves. They complain that women's ideas have been moulded by men, in conformity to the state of subordination in which the weaker sex has been held, and that the first thing women have to do is to assert themselves mentally, to develop their own powers in their own way, to form their own opinions, and not be forever dependent upon those who by the radical bias of an opposite constitution are incapable of comprehending woman or of doing justice to her capacities. On this ground it is of course impossible for woman to accept a masculine education. For the existing colleges and universities have not only been originated and developed through centuries exclusively by men, but they have been pervaded by the thoughts and animated by the feelings and tastes, and moulded by the aims and necessities, of men. If women are to free themselves from male control in the matter of one-sided mental influence, it would seem that their first care should be not to *subject* themselves to the action of those institutions the very object of which is to assimilate and determine the intellectual character of students into harmony with their own policy.

We yield to no others in the earnestness of our belief in the higher education of women; but we want to see them take the matter in their own hands, and work out a system of mental

cultivation adapted to their own natures and needs. The higher education as embodied in existing institutions cannot meet this requirement. It is, in fact, under indictment for non-adaptation to the present wants of men; and one of the most profound and important of the reforms of our age is that thorough modification of collegiate methods of study that shall bring them up to the demands of modern life. That they now answer to these demands, but very few will maintain. There are many, and the number is increasing, who do not go to college because the education there obtained is thought to be of little use to the possessor, if not indeed a hindrance to him in his future experience with the world. Thousands ignore all considerations of the usefulness of what is to be learned, and go or are sent to college because it is the proper thing, a fashion of society, and has its social benefits; and many undoubtedly go because they have been made to believe that the old education is the perfection of human wisdom for mental discipline, and is, after all, the best thing even for practical life. Yet the distrust of the system is deep, and has already made itself so powerfully felt, that the colleges have been compelled to yield to it, and in many cases to modify their methods of instruction and create supplemental schools devoted to modern knowledge. The higher education of men is thus in a state of conflict and transition; the old education is giving way, and a New Education is rising in its place.

It seems to us that this is the first fact for women to consider in their efforts to attain a higher education. The question that is forced upon men, What shall the higher education be? has even a graver concern for women, for it is not only an open one, but it is an experiment which must be submitted to the test of time, and if mismanaged may be full of peril. It behooves women not to be so carried away by the current clamor about the advantages of education, that they are willing to accept any thing under that name that is dispensed from the schools. Education, like every thing else, may be good or bad, worthless or valuable; but it differs from most other things in this, that, if bad and worthless, it cannot be got rid of. We have yet to realize the important fact that much so-called education is worse than none at all; and that it is better to leave the mind to its spontaneous forces and its self-development under the action of the surrounding influences of Nature and life, rather than to meddle with it inconsiderately, to burden it with worthless knowledge, or to violate its proportions by an extravagant over-culture of some faculties and a total neglect of others. Were the doors of all the colleges of the country to be opened to-morrow to woman, in good faith, and in obedience to a public sentiment that would lead her to avail herself of the opportunity as men do, we believe that the result could not be otherwise than in a high degree disastrous to woman and to society; and this because the education which she would get would be not what she requires, would be put in the place of what she requires, and would indefinitely postpone the attainment of what she requires.

It is well for woman that, in awakening to the necessity of a higher cultivation of her faculties, she is free in the choice of means; but it remains to be seen what she will do with her chance. There is superabounding knowledge, the ripening of all the past—wheat and chaff; there is the world's long experience with education for help or for warning; what, then, will woman do toward constructing a higher education for herself? Will she follow blindly the old traditions, content with any thing, and accept the culture that man has outgrown and is rejecting; or will she be equal to the occasion, and form

for herself a curriculum of studies suited to the requirements of her own nature?

That woman has a sphere marked out by her organization, however the notion may be scouted by the reformers, is as true as that the bird and the fish have spheres which are determined by their organic natures. Birds often plunge into the watery deep, and fishes sometimes rise into the air, but one is nevertheless formed for swimming and the other for flight. So women may make transient diversions from the sphere of activity for which they are constituted, but they are nevertheless formed and designed for maternity, the care of children, and the affairs of domestic life. They are the mothers of humankind, the natural educators of childhood, the guardians of the household, and by the deepest ordinance of things they are this, in a sense, and to a degree, that man is not. For woman in these relations, education has hitherto done but little, and humanity has suffered as a consequence. To the mothers of the race, especially, belongs the question of its preservation and improvement. The problem is transcendent, and woman's interest in it more immediate and vital than man's can be. Science has furnished the knowledge that is required, a vast mass of truth that is waiting to be applied for the conduct and ennobling of the domestic sphere. Man has originated it; is it not for woman to use it? And now, when there is so much agitation to give woman larger mental opportunities, and she is pressing for the advantages of a higher education, we have a right to expect that she will consider the subject from her own point of view, and supply the great educational need that has been so long recognized and deplored. The new departure of higher female education should unquestionably be from the results of the medical profession. We believe that physicians have by no means yet taken the share in general education that the interests of society require; but, when the mental cultivation of women is to become systematic and they have their own higher institutions, the agency of physicians will be indispensable. It is not that all women are to be doctors, but that they are to be instructed and become intelligent first of all in the sciences of life, with which also the physician has to deal. If, to get the A. M. of Yale or Harvard, would be worth the struggle for women, as qualifying them for the intelligent fulfillment of their destiny, let the doors be battered down if necessary for their entrance; but, if it would not conduce to this end, and would rather be fatal to it, let the doors remain double-locked. If the present aspiration is to be utilized, the movement must not take a false direction. New institutions are called for, that shall supply a new education on the feminine side. The system of studies may be broad and liberal in the best sense, but what we insist on is that it should be shaped with fundamental reference to the life-needs of female students. From this point of view our existing female colleges are liable to criticism; in so far as they are imitations of the old masculine establishments, they do not meet the wants of the sex, and rather obstruct than aid the true course of feminine cultivation.

EXPERIMENTS UPON LIVING ANIMALS.

THERE is no element of human nature more noble than that sympathy with inferior creatures which leads to a kindly regard for their welfare, and protects them from wanton or careless suffering; and it is gratifying to observe that this feeling is becoming so definite, so strong, and so extended, as to have embodied itself in organizations for the systematic prevention of cruelty to animals. With all our boasted civ-

ilization and enlightenment, men are yet very much barbarians, and the cruel instincts of the savage still animate many a nominal Christian. The humaner feelings are beginning to assert their influence; but they encounter fearful odds in the struggle with hereditary impulses to violence, and that artistic refinement of brutality which seeks enjoyment in the suffering of inferior creatures.

Yet, like every thing else, the kindly sentiments toward animals may be carried to extremes and run into absurdity. We live in a world, or at least in a stage of it, in which suffering is not to be escaped. By the constitution of things, it must be inflicted. Older than the Decalogue, older than man, as old as the earliest life, is the divine ordinance of Nature to kill or be killed. The necessity of mutual destruction was instituted in the nature and with the first appearance of living things. Not only was death the doom of all, but death by violence and mutual ruthless slaughter was the necessary and normal result of the arrangement. The world has advanced through agony, and, in its unfolding, the price of higher enjoyment has ever been intenser pain. As the nervous system of the animal series has become more voluminous, delicate, and complex, the capacity of suffering as well as pleasure is increased; and, in the most perfected being, the very flowering of genius opens new susceptibilities for painful emotion of which natures with lower gifts know nothing. Pain, therefore, is not to be escaped. Each sentient creature by the law of its being strives to avoid it, and it is incumbent upon all to lessen it as far as possible, but it is wrought into the inexorable economy of things, and not to recognize and deal with it as any other fact is irrational.

It hurts insects to be killed, but we must kill them in self-defense. We destroy the lower animals for our food, but there is a deeper reason for being rid of them, because, if suffered to multiply unchecked, they would put an end to us. It will therefore not do to yield in this matter to the pure dictates of sentiment. There is an infliction of pain that is reasonable and necessary, and one of the cases of it is afforded by the physiologist who makes painful experiments upon the lower animals to extend the knowledge of his science. As the exigencies of diet may require us to slay an ox, so the demands of scientific truth may require us to sacrifice a rabbit or a dog. In both cases the pain produced should be the least possible, but in both the ends are reasonably held to justify the infliction. Yet there have been many and earnest protests against vivisection, or experiments upon living animals, as an inexcusable cruelty; and physiologists have recently been the subjects of a fresh assault by sentimental writers in the London literary press. The arguments in favor of the practice are so convincingly stated, and the objections to it so well refuted, in a paper by Dr. Foster, of Cambridge, that we reproduce it in the present number of the MONTHLY. It will well repay perusal.

LITERARY NOTICES.

ENGLISH PSYCHOLOGY. Translated from the French of Théodore Ribot,[1] Professor of Philosophy in the Lycée at Laval. New York: D. Appleton & Co. 328 pp. Price, $1.50.

THE study of the human mind is beyond all doubt one of the most sublime and important, as it is certainly one of the most difficult, of all studies. So great is its interest that it has fascinated philosophers for thousands of years, and so great is its difficulty that of all branches of inquiry it has proved least amenable to investigation, and has led to the most discordant conclusions. From the beginning of speculation it has been pursued by a method that has failed to

[1] Pronounced Rebo.

yield agreement or results that have compelled the general acceptance of thinkers. Its problems were too complex, subtile, and exalted, to be effectually dealt with before men had been trained to the work of investigation on the subordinate planes of natural phenomena. The lower before the higher, the simple before the complex, must be the law of movement where not only truths of the highest order are to be reached, but the methods by which they are to be arrived at have also to be discovered. There was needed a long and severe apprenticeship of science in the work of unraveling phenomena before the realm of mind could be entered with any confidence of its conquest. And it was not only necessary to learn by scientific practice the difficult art of investigation, but the solution of mental problems was vitally dependent upon a species of knowledge which ordinary science alone could disclose. Of mind, as a phenomenon to be investigated, we know nothing whatever, except as a manifestation of organic life. It is conditioned by organic laws, and there can be no competent mental science that does not recognize this truth. Mind, moreover, is exhibited, with a thousand modifications, through all the grades of animate being, and these diversities must be regarded by any true science of the subject. The psychical natures of the quadruped, the bird, the fish, the insect, may not be so dignified as that of man, and may afford less inspiring themes for declamation, but, in a scientific point of view, they are of equal interest, and their investigation is imperative. It could not be otherwise, therefore, than that mental philosophy should be profoundly affected both by that drill in research and that extension of knowledge which have resulted from the last three centuries of scientific progress. The new phase which the subject has consequently assumed is known as the Modern Psychology or the New Psychology, and this has given rise to a school of thought, the most eminent representatives of which are Englishmen. With a few exceptions, and those of hardly the highest mark, Germany clings to the old methods. France is behind the age in every thing, our own country is crippling along after European traditions, and it is left to England to pioneer the world in the work of psychological development.

Prof. Ribot's book is the tribute of a candid and unprejudiced foreigner to the greatness of the English school of scientific psychology, and it is an admirable analysis of the contributions of the representative English writers upon this subject. An enthusiastic student of philosophy himself, and thoroughly imbued with the scientific spirit, Prof. Ribot brings eminent qualifications to his task, and grasps the subject with the power of a master, while his work has a judicial fairness in the estimate of men that is favored by his foreign point of view. He writes, moreover, with a point and clearness that are quite unusual in treating this class of subjects. Prof. Ribot gives us in this volume a lucid account of the systems of Hartley, James Mill, Herbert Spencer, Alexander Bain, George H. Lewes, Samuel Bailey, and John Stuart Mill, and his work altogether affords the best delineation we have of the positions and grounds of the New Psychological School that has come forward into such prominence in the present generation.

Prof. Ribot prefixes to his volume an admirable and instructive introductory chapter on the relations of philosophy, science, and metaphysics, and the gradual growth and present position of scientific psychology. In his section considering the several definitions of it, he remarks as follows concerning one of them:

"We are told that psychology is the science of the *human* soul. That is a very narrow and incomplete idea of it. Is biology ever defined as the science of *human* life? Has physiology ever believed, even in its infancy, that its only object was man? Have they not considered, on the contrary, that every thing which has organized and manifested life belongs to them—the infusoria, as well as man? Now, unless we admit the Cartesian opinion of animal machines—which has no longer, to my knowledge, an adherent—we must acknowledge that animals have their sensations, their sentiments, their desires, their pleasures, their pains, their character, just like ourselves; that there is a collection of psychological facts which one has no right to subtract from the science. Who has studied

those facts? The naturalists, and not the psychologists. If we were to go further, we might show that ordinary psychology, in restricting itself to man, has not even included the whole of mankind; that it has taken no heed of the inferior races (black and yellow); that it has contented itself with affirming that the human faculties are identical in nature and various only in degree, as if the difference of degree might not sometimes be such as to be equivalent to a difference of nature; that in man it has taken the faculties already constituted, and rarely occupied itself with their mode of development; so that, finally, psychology, instead of being the science of psychical phenomena, has simply made man, adult, civilized, and white, its object.

"We have seen how psychology understands its object, let us now see how it understands its method. This consists entirely in reflection, or interior observation. Assuredly, no one believes more firmly than we do in the necessity of this mode of observation; it is the point of departure, the indispensable condition of all psychology, and those who have denied it, like Broussais and Auguste Comte, have so completely gone against evidence, and given the game to their adversaries, that their most faithful disciples have not gone so far with them. It is certain that the anatomist and the physiologist might pass centuries in studying the brain and the nerves, without ever suspecting what a pleasure or a pain is, if they have not felt both.

"No testimony is so valuable on this point as that of consciousness, and we are always brought back to that saying of an anatomist—'In the presence of the fibres of the brain, we are like hackney-coachmen, who know the streets and the houses, but know nothing of what takes place inside them.' It is also certain that the objections made to this method of observation have been very well discussed. But is it true that interior observation is the *unique* method of psychology? that it reveals every thing, that it suffices for every thing? Taken in its rigorous meaning, this doctrine would lead to the impossibility of the science. For, if my reflection apprises me of that which passes in me, it is absolutely incapable of enabling me to penetrate into the mind of another. A more complicated process is necessary for that. We are talking; a man present at our conversation joins in it with an absent manner, says a few words with evident effort, and forces a smile; I *conclude* from all this that he is a prey to some hidden trouble. I may soon divine its causes if I have a penetrating mind, and if I am acquainted with this man and his antecedents. But this psychological discovery is a very complex operation, of which the following are the stages: perception of signs and gestures, interpretation of those signs, induction from effects to causes, inference, reasoning by analogy. It has nothing in common with interior observation except that aptitude for knowing others better which comes from knowing one's self better. Thus, one of two things is the case: either psychology is limited to interior observations, and, these being completely individual, it has no longer any scientific character; or else it is extended to other men, it searches out laws, it practises induction, it reasons, and then it is susceptible of progress; but its method is to a great extent objective. Interior observation alone is not sufficient for the weakest psychology."

INTERNATIONAL SCIENTIFIC SERIES, NO. VIII.

ANIMAL LOCOMOTION; OR, WALKING, SWIMMING, AND FLYING. With a Dissertation on Aëronautics. By J. BELL PETTIGREW, M. D., F. R. S. New York: D. Appleton & Co. 264 pp. Illustrated. Price, $1.75.

LOCOMOTION by steam began but a few years since; its principles are simple, and the machines by which it is accomplished are all of one general construction; yet we have already whole libraries of literature—folios, quartos, and octavos, cyclopædias, essays, and catechisms, technical and popular—expounding and explaining it. Much also has been written in elucidation of the principles and mechanisms of progression that are illustrated in the animal kingdom; but the present volume of Dr. Pettigrew is the first popular monograph on the subject that we have seen, and, although not large, it contains much curious and interesting information upon all aspects of it. But the

chief interest of Dr. Pettigrew's book for thoughtful readers will consist in the skillful way he strikes through those diversities of movement and medium which are involved in the three forms of progression, and brings out the principles that are common to all. "We are apt," he says, "to consider walking as distinct from swimming, and walking and swimming as distinct from flying, than which there can be no greater mistake. Walking, swimming, and flying are, in reality, only modifications of each other. Walking merges into swimming, and swimming into flying, by insensible gradations. The modifications which result in walking, swimming, and flying, are necessitated by the fact that the earth affords a greater amount of support than the water, and the water than the air. That walking, swimming, and flying, represent integral parts of the same problem, is proved by the fact that most quadrupeds swim as well as walk, and some even fly, while many marine animals walk as well as swim, and birds and insects walk, swim, and fly, indiscriminately."

The problem thus becomes interesting from the unity of its fundamental laws, but for the author it has more than a speculative interest; it has a scientific importance as furnishing conditions for solving the problems of artificial progression.

Upon this point he remarks: "The history of artificial progression is essentially that of natural progression. The same laws regulate and determine both. The wheel of the locomotive and the screw of the steamship apparently greatly differ from the limb of the quadruped, the fin of the fish, and the wing of the bird; but, as I shall show in the sequel, the curves which go to form the wheel and the screw are found in the traveling surfaces of all animals, whether they be limbs (furnished with feet), or fins, or wings.

"It is a remarkable circumstance that the undulation or wave made by the wing of an insect, bat, or bird, when those animals are hovering before an object, and when they are flying, corresponds in a marked manner with the track described by the stationary and progressive waves in fluids, and likewise with the waves of sound.

"Of all animal movements, flight is indisputably the finest. It may be regarded as the poetry of motion. The fact that a creature as heavy, bulk for bulk, as are many solid substances can, by the unaided movements of its wings, urge itself through the air with a speed little short of that of a cannon-ball, fills the mind with wonder. Flight (if I may be allowed the expression) is a more unstable movement than that of walking and swimming, the instability increasing as the medium to be traversed becomes less dense. It, however, does not essentially differ from the other two, and I shall be able to show, in the following pages, that the materials and forces employed in flight are literally the same as those employed in walking and swimming."

These passages foreshadow the character of Dr. Pettigrew's book. He works out the principles of animal locomotion as a further step in the progress of artificial locomotion, by which the theoretical issues in the practical. After an elaborate analysis of the anatomical and dynamical conditions of flight, he goes into the question of its imitation by art, and points out the conditions on which he thinks the problem may be ultimately solved. Here, of course, he launches into an untried field, abounding with difficulty, and open to a diversity of opinions. Already a brisk controversy has sprung up in the London journals over his theory of flight, and the question of precedence in its elucidation between the French and the English; but, whatever may be its merits, the interest of Dr. Pettigrew's contributions to the question in the present volume will remain unaffected. We should not omit to state that the volume is profusely and beautifully illustrated with original cuts and plates.

PRANG'S NATURAL HISTORY SERIES OF COLORED CHROMOS. For Schools and Families. Classified by N. A. CALKINS; 14 large Plates; 192 Cards. Price of full set, $10. J. W. Schermerhorn & Co., Agents, 14 Bond Street, New York.

MR. PRANG, having achieved fortune and fame in the cultivation of the chromo-lithographic art in the department of fancy pictures, has at length turned his attention to education, and applied it to the illustration of objects of natural history. A large num-

ber of specimens of plants and animals, selected by Mr. Calkins to represent the more interesting groups of organic forms, are printed in colors upon cards for convenience of handling in the class-room. It needs not to be said that these illustrations are beautifully executed, and cannot fail to prove in a high degree attractive to children. That they have been executed with care and correctness, under the vigilant direction of Mr. Calkins, there can be no doubt. As to their utility in education, that will depend entirely upon the teacher and the policy of the school. If employed as guides to the study of real objects, they cannot fail to be helpful; but, if subordinated to the usual system of study, and accepted in place of the things they represent, they will have simply the value of excellent pictures, and will add to the already immense mass of hindrances and stumbling-blocks which the schools interpose between the minds of children and the objects of Nature.

THE STONE AGE, PAST AND PRESENT, by E. B. TYLOR; and THEORY OF NERVOUS ETHER, by Dr. RICHARDSON, F. R. S. Boston: Estes & Lauriat. Price, 25 cents.

THIS is No. 9 of "Half-Hour Recreations in Popular Science." The first paper is a popular account of the stone age, or, as the author puts it, "of that period in the history of mankind during which stone was habitually used as a material for weapons and tools." This period he divides into two parts, the first of which he calls the Underground Stone Age, when the implements employed were merely chipped out, and used in a comparatively rough and imperfect shape. Such implements are found in greatest abundance in the Drift or Quaternary Deposits, and in the early bone-caves, and consist largely of chipped flints, apparently designed for spear-heads, arrow-heads, scrapers, knives, etc. The second or later division of the period above referred to—the Ground Stone Age—is characterized by the employment of ground and often polished instruments of stone, much more perfect than the chipped forms, and therefore denoting a higher stage of human progress. Stone implements are found in nearly every part of the world, and, whatever their source, show a remarkable uniformity of pattern. This latter feature the author accounts for partly on the principle that man does the same thing under the same circumstances, and partly on the belief that the art was derived by one race from another. The evidences of the stone age, brought to light in the countries hitherto explored, take up the remainder of the paper. Any one wishing a general idea of what is at present known on this interesting subject, will be well repaid by a perusal of this essay.

The theory of a nervous ether we will give in the author's own words: "The idea attempted to be conveyed by the theory is, that between the molecules of the matter, solid or fluid, of which the nervous organism, and indeed of which all the organic parts of the body are composed, there exists a refined, subtile medium, vaporous or gaseous, which holds the molecules in a condition for motion upon each other, and for arrangement and rearrangement of form; a medium by and through which all motion is conveyed; by and through which the one organ or part of the body is held in communion with the other parts, and by and through which the outer living world communicates with the living man—a medium which, being present, enables the phenomena of life to be demonstrated, and which, being universally absent, leaves the body actually dead; in such condition, i. e., that it cannot, by any phenomenon of motion, prove itself to be alive." The paper is devoted to an elucidation of this theory.

INSECTS OF THE GARDEN: Their Habits, etc. By A. S. PACKARD, Jr. Boston: Estes & Lauriat. Price, 25 cents.

THIS is the first part of a volume from the pen of Prof. Packard, entitled "Half-Hours with Insects," to be issued in twelve parts, of about 36 pages each, by the above house. Beginning with some general considerations on the relations of living objects to one another, the author passes thence to the subject of agriculture, and the manner in which its interests are affected by the incursions of insects. Numerous instances are given of their terrible destructiveness to crops, which, though apparently insignificant when estimated, say, for

a single township, amounts to something almost incredible when an entire State or country is included in the calculation. According to the reports of Dr. Fitch, $12,000,000 worth of wheat has been destroyed in the State of New York, in a single year, by the wheat-midge and Hessian-fly. An interesting account is next given of the reproduction, growth, and metamorphosis, of insects, with some remarks on their psychology, their relations to each other, and their relations to other animals. The last twelve pages are devoted to the insects of the garden, some of the more noxious of which are described, their habits sketched, and the means of combating them indicated. A beautiful chromo-lithograph, showing the different stages of insect metamorphosis, heads the issue, and the succeeding pages abound with well-executed illustrations. For clearness and vigor of style, the name of the author is sufficient guarantee.

MANUAL OF PHYSICAL GEOGRAPHY AND INSTITUTIONS OF THE STATE OF IOWA. By C. A. WHITE, Professor of Geology in the State University. Davenport: Day, Egbert & Fidlar. 1873.

THIS book was made for use in the schools of Iowa, being limited to the physical geography and institutions of that State. This has enabled the author to give a large amount of information, locally valuable, that would be obviously out of place in a more general work. For convenience, the book is divided into two parts. Part I. gives an account of the leading natural features of the State—its physical geography, geology, climate, soil, minerals, and natural history. Part II. deals with the history of the State, and includes an account of its educational, charitable, and penal institutions. The few who may desire to carry the study into a wider field, will find the mastery of this work an excellent preparation.

THE THEORY AND PRACTICE OF LINEAR PERSPECTIVE. Translated from the French of V. Pellegrin. New York: Putnam's Sons. 51 pp., with colored chart.

THE author claims that books of this kind are generally too theoretical, and that he has aimed to make this especially practical. It was adopted by the educational authorities of Paris, and commended by them as a "little book which, under a modest form, contains ideas of which the popularization would be of great use—'The Practical Theory of Perspective,' a study for the use of artists, etc., by Monsieur V. Pellegrin, late Professor of Topography at the Military School of St. Cyr. The author, himself a painter, and accustomed to the manipulation of geometrical methods, was particularly qualified for writing this treatise; and he has been able, by dint of research and ability, to condense into a small number of pages the laws of perspective; and to extract, from a confused mass, rules which are very simple and easily applicable to every possible case; thus placing a sure and clear guide within the reach of all students, artists, and amateurs. Monsieur Pellegrin's excellent treatise will become a standard work."

SUBMERGED AND DIFFERENT FORMS OF RETAINING WALLS. By JAMES S. TATE, C. E. New York: D. Van Nostrand. 1874. Price, 50 cents.

THIS is No. 7 of the publisher's "Science Series." The simple statement of what the author has proposed to himself to accomplish will be the best evidence of the value of this little manual. His object was to furnish to engineers a certain and ready means of ascertaining the pressures of embankments, submerged or otherwise, composed of different materials; also the moments of retaining walls, of different forms of cross-section, to successfully withstand those pressures. By having this little book at hand, the engineer will be saved the trouble of many a long calculation.

HOW TO BECOME A SUCCESSFUL ENGINEER. By BERNARD STUART. New York: D. Van Nostrand. 127 pp., 18mo. Price, 50 cents.

THIS little work, which is designed particularly for the mechanical engineer, but, in a more general way, also for the civil engineer, is more indicative than instructive. That is, it points out the studies to be pursued without explaining their nature, and it tells the apprentice what work he will find in the machine-shop, without detailing the method in which it is done. It contains some practical suggestions on the im-

portance of good habits, self-reliance, and dexterity of hand.

LEGAL RESPONSIBILITY IN OLD AGE. By GEORGE M. BEARD, A. M., M. D. New York: Printed by Russell's American Steam Printing-House; 42 pp., 8vo.

THIS is an address delivered before the Medico-Legal Society of New York, in March, 1873. It discusses the effects of age on the mental faculties, as evidenced in the works of the greatest men of all times. The author states that his method was to study the biographies of such men, and observe the average age at which their best works were produced. The conclusion reached is, that the best work is done between thirty and forty, the worst between seventy and eighty, and that the growth, maturity, and decay, of the mind, are coeval with the corresponding stages of the body. As a corollary, it is held that the moral faculties also decay with the downward curve of life. The fact is pointed out that one or more of the moral faculties may decay, while the rest remain sound. The address concludes with an earnest protest against the prevailing mode of testing moral responsibility in courts of law, and recommends, as an improvement, the appointment by the States of an examining commission, composed of from three to five psychological experts. It is both interesting and instructive.

PHYSICAL GEOGRAPHY. By JOHN YOUNG, M. D., L. R. C. S., etc. New York: G. P. Putnam's Sons. 368 pp. Price, $1.50.

THIS book is a condensed statement of the principal geological and biological truths and such astronomical facts as relate to the earth. In the introductory chapter, the author thus describes the sphere of his subject: "Physical geography takes up the results achieved in all these departments—geology, biology, and astronomy—and proceeds to higher generalizations. It shows how the behavior of the earth, as a body in space, and its relations to other bodies, determine the atmospheric currents, and, through them, the movements of the ocean; it points out how the ocean-currents modify and are affected by the tides; it determines the extent to which the character and variation of the climate are dependent on secular changes. The changes of sea and land, as ascertained by the geologists, are used to explain the movements of organized forms, and the biologist finds, in atmospheric, topographical, and climatal influences, the key to the presence or absence, the abundance or scarcity, of particular groups in any locality."

In connection with the composition of the earth's crust, are described the classification, formation, and chemical constitution of rocks; also the production and geological importance of fossils. The configuration of the earth's surface, or the distribution of land and water, with the changes it has undergone; the formation of islands and continents; ocean and atmospheric currents; forms of water in the atmosphere, as snow, rain, mist, etc.; climate and weather, are briefly though clearly set forth. Apparently the only fault of the book is that less space has been devoted to describing the distribution of plants and animals than the importance of the subject demands. As may be inferred from its nature, the book contains no new truths, but its value suffers no impairment therefrom. It has the merit of being free from the influence of particular theories, and, where unsettled questions are discussed, the author conscientiously endeavors to give the reader the drift of scientific opinion.

THE BIRTH OF CHEMISTRY. By G. F. RODWELL, F. R. S., F. C. S. London: Macmillan & Co. 135 pp., 12mo. Price, $1.50.

THE origin of chemistry is herein traced through the grotesque alchemic vagaries of the middle ages to the natural philosophy of the ancient Greeks and their contemporaries. The quaint admixture of truth and error, constituting their so-called natural philosophy, is first shown. The ideas of primary elements and their transmutations; the metals known to the ancients and the manner in which they were worked; ancient colors and chemical compounds, are all described in a manner calculated to please the general reader. The origin of alchemy is traced to Arabia about the fourth century A. D. The mysteries of alchemy are likewise detailed, as well as the theories of combustion and phlogiston, out

of which legitimate chemistry was developed about 150 years ago, by the efforts of Boerhaave, Lavoisier, and others.

ESSAYS ON EDUCATIONAL REFORMERS. By R. H. QUICK, M. A. Cincinnati: Robert Clarke & Co. 326 pp., 12mo. Price, $2.00.

THIS is a review of the principal educational doctrines, beginning with the once famous schools of the Jesuits, and ending with Herbert Spencer. The main features of each doctrine are given and commented on in a liberal tone. The author differs from Mr. Spencer in some important points, such as the worthlessness of ordinary history, the value of the sciences, and the position fine arts and belles-lettres should occupy in education. In the two concluding chapters he gives his own views on secular education and moral and religious training. Outlines of the lives of the earlier Reformers are given in connection with the discussion of their doctrines. The work possesses value as a history of modern education.

PUBLICATIONS RECEIVED.

The Border-Land of Science. By Richard A. Proctor, B. A. J. B. Lippincott & Co. 1874.

The Structure of Animal Life. By Louis Agassiz. New York: Scribner, Armstrong & Co. 1874.

A Manual of Inorganic Chemistry—the Non-Metals. By T. E. Thorpe, Ph. D. New York: G. P. Putnam's Sons.

Animal Physiology, and the Structure and Functions of the Human Body. By John Cleland, M. D. Putnam.

Politics and Mysteries of Life Insurance. By Elizur Wright. Lee & Shepard. 1873.

Inorganic Chemistry. By W. B. Kemshead. Putnam.

Addresses and Proceedings of the National Educational Association. Published by the Association. 1873.

An Elementary Treatise on Steam. By John Perry, B. E. Macmillan. 1874.

The Galvanometer and its Uses. By C. H. Haskins. Van Nostrand. 1873.

Building Construction. Putnam.

Elements of Zoology. By M. Harbison. New York: Putnam.

Bulletin of the Bussey Institution. Boston. Pp. 80.

The Progressive Ship-Builder. By John W. Griffiths. Illustrated. New York: The Nautical Gazette Print. 1874. Pp. 32.

Notice of New Equine Mammals from the Tertiary Formation. By O. C. Marsh. Pp. 12.

Twenty-second Annual Report of the Detroit Water Commissioners. 1873.

Report of the Committee on the Yellow-Fever Epidemic. Shreveport Medical Society.

Uncivilized Man. A Lecture by Bishop Cotterill, of Edinburgh. Edinburgh: R. Grant & Son. 1874. Pp. 30.

Bulletin of the United States Geological and Geographical Survey of the Territories. No. 1. Washington: Government Printing-Office. 1874. Pp. 28.

A Short Treatise on the Compound Steam-Engine. By John Turnbull, Jr. New York: Van Nostrand. 1874. Pp. 43.

MISCELLANY.

Rumford's Discoveries in Thermodynamics.—In his sketch of the growth of the science of thermodynamics, Prof. P. G. Tait, of the University of Edinburgh, rates the services of Count Rumford second in importance to those of Davy, and does not apparently consider them comparable to those of Joule. Prof. R. H. Thurston, of the Stevens Institute of Technology, in a note relating to Rumford's determination of the mechanical equivalent of heat, points out the injustice of this proceeding, on the part of Prof. Tait, and says that "we may claim for Rumford: 1. That he was the first to prove the immateriality of heat, and to indicate that it is a form of energy, publishing his conclusions a year before Davy; 2. That he first, and nearly a half-century before Joule, determined, with almost perfect accuracy, the mechanical equivalent of

heat; 3. That he is entitled to the sole credit of the experimental discovery of the true nature of heat. BENJAMIN THOMPSON, of Concord, New Hampshire, commonly known as Count Rumford, should be accorded a nobler position and a higher distinction than he has yet been given by writers on thermodynamics."

Antiquity of Man.—R. H. Tiddeman publishes in *Nature* an interesting paper on the "Relation of Man to the Ice-sheet in the North of England," in which he describes, with some detail, the fossils found in Victoria Cave, in Yorkshire, now being explored by a committee, aided by the British Association. In this cave discoveries of a most interesting character have been made. In a bone-bed, beneath other deposits, were found bones, teeth, and other remains of extinct species of animals. Prof. Burke identified remains of the *Elephas primigenius*, rhinoceros, cave-bear, hyena, bison, and others, and among these remains was a human bone, a somewhat clumsy fibula (small bone of the leg). Of this Mr. Busk says: "The relic is human; there is no room for the slightest doubt on the subject." And this opinion is fully confirmed by Prof. James Flower, of the College of Surgeons.

The position of the locality in which this bone was found makes its discovery of great importance. It seems to carry back the period when man existed to glacial if not to preglacial times.

Trout from an Artesian Well.—In the *Journal of Science and Art* we find a note from Mr. A. W. Chase, giving the following curious information, which the author received from Mr. Bard, agent of the California Petroleum Company at San Buenaventura: Mr. Bard, wanting water to supply a newly-constructed wharf at Point Hueneme, southeast of San Buenaventura, commenced sinking an artesian well on the sea-beach, not five feet from high-water mark. At the depth of 143 feet a strong flow of water was obtained, which spouted forth to a height of 30 feet. It was controlled with a "goose-neck," and utilized. One day while the agent was absent, the men around the well noticed fish in the waste water. On his return, they called his attention to the fact, and, on examination, the well was found to be filled with young trout, thousands of them being thrown out at every jet. These trout were all of the same size (about two inches long), and perfectly developed. The first examination was made to see whether they had *eyes*. These were found perfect. Now, there is no stream nearer than the Santa Clara River, several miles distant. Could these fish, then, have come from its head-waters by some subterranean outlet? There are no trout in the lower portions of the stream. The temperature of the water is the same as that of the wells all around, viz., 64° Fahr., too warm, of course, for trout to live in it long.

Atkins Charcoal Filters.—The Atkins system of filtering water is spoken of in terms of high commendation in *Iron*, from which journal we take the following description of the system: The best and purest animal charcoal is ground and pulverized until it is brought into the finest possible state of comminution, and, thus prepared, it is mixed up with a definite proportion of Norway tar, and a compound of other combustible ingredients. The combined materials are then thoroughly amalgamated with liquid pitch, and the whole kneaded up into a homogeneous plastic mass, which admits of being moulded into slabs or blocks of any required dimensions and shape. These blocks having been allowed to dry and harden, are subsequently carbonized by being subjected to a process of incineration by heat; and, in this manner, all the combustible ingredients are burnt out of the block, leaving nothing behind but the animal charcoal in the form of a block of charcoal, permeated throughout by innumerable pores, admirably adapted for the mechanical infiltration of fluids, while subjecting them, in a minutely subdivided state, to the chemical absorptive and purifying action of the carbon itself.

These carbon-blocks are chiefly cast in cylindrical forms, so arranged that the percolation is from the external periphery inward, and the centre of the block is hollow, forming a tube whence the filtered water flows. In this way the bulk of the impurities is deposited on the outside of the block, whence it may be removed by washing with

hot water, or by scraping. Such filters, singly or in numbers, are placed in the bottom of a cistern, the central pipes of efflux being all connected together, and with one outlet. Where a large filtering capacity is required, a different principle is adopted, viz., a series of carbon-plates. In this case the water, in its passage from the inlet to the outlet, is caused to pass through a number of frames, variously constructed, according to circumstances. Thus there may be, firstly, a frame, covered with fine wire gauze; then separate frames, paneled with carbon-plates, with or without the intervention of a bed of pure loose animal charcoal, filling up the spaces between them; and there may be also a double frame, containing a sheet of felt compressed between two perforated plates, made respectively of sheet-copper and zinc, which would exert a certain electrical action, and aid in the chemical action of precipitating impurities. The system may be used for filtering the water-supply of a town.

Apart from this hygienic use, these carbon-blocks may be employed for many industrial purposes. Experiments have shown them to be efficacious in removing deleterious gases, and other soluble substances held in solution in fluids. They are applied as filters for wines, oils, and syrups; and, above all, they merit attention as an adjunct to the feed-water apparatus of steam-boilers, inasmuch as efficient filtration affords the best, cheapest, and surest method for preventing incrustation in boilers.

Cremation.—An eccentric will, wherein the testator requested that his body might be consumed in a gas-retort, and thus made to contribute to the enlightenment instead of the poisoning of the world, has survived the long-forgotten subject of cremation. Without doubt, Mr. Trelawney's hideously-graphic description of the burning of the body of Shelley has greatly contributed to prejudice the public mind against the cleanest and best method of getting rid of the "mortal coil." But the ceremony at Spezzia was conducted in the most bungling fashion, and a want of scientific appliances contributed to the incompleteness, and, therefore, to the horror of a simple operation. A retort gets rid of the entire difficulty, and, both from a utilitarian, a scientific, a sanitary, and a poetic point of view, the mausoleum, decked with cinerary urns, possesses immense advantages over the damp and unwholesome graveyard, exhaling pestiferous odors, to which modern nations, for some inscrutable reason, are preposterously wedded.—*Iron*

Death of Dr. Forbes Winslow. — Dr. Winslow was born in London in 1810. He began his medical studies in New York; took the degree of M. D. at King's College, Aberdeen, and became a member of the Royal College of Surgeons, London, in 1835. His first published works appeared in 1831, since which time he has made numerous important contributions to the literature of medicine, chiefly in the department of nervous and mental diseases. His most valuable work in this line, "The Obscure Diseases of the Brain, and Disorders of the Mind," was published in 1860, and has since passed through several editions. He died in London, on March 4, 1874.

The Economy of Beer.—Prof. Max von Pettenkofer, the eminent Munich chemist, states that, to make a quart of good beer, there is required, at least, a pint of good barley, besides hops, etc. The product contains not a single trace of albumen, and only a very small percentage of alimentary principles: in short, it is only a *condiment*, not a food-stuff properly so called. The question now arises, Would it not be better to send this barley to the mill, and make of it a bread-stuff, instead of brewing from it a costly beverage, which contributes little or nothing to the system? Or, better still, Would it not be advisable to grow, in place of barley and hops, wheat and rye, either of which would give better bread than barley?

Prof. Pettenkofer holds that the need of mere condiments is no less imperative than the need of food-stuffs, properly so called. "Butter and cheese," says he, "are neither as good nor as complete food-stuffs as milk, and yet butter and cheese are made, and will continue to be made, even though it were possible to transport milk in good condition to considerable distances." The same is to be said of barley and beer. Prof. Pettenkofer observes that

the consumption of beer is steadily increasing in spite of the advance in prices, and he is convinced that this state of things will continue, no matter what weight of argument may be brought against it. "Condiments of this kind," says he, "are often, no doubt, the occasion of real waste, but yet the majority of mankind can always, to their great profit, find, by observation and self-control, the proper amount of them to consume"

Sensation and Motion in Plants.—Treating of the vital phenomena which are common to plants and animals, the eminent French physiologist, Claude Bernard, observes that Linnæus's criterion of animality, viz., sensibility and mobility, is not in accord with facts. There are many plant-forms on the boundary between the animal and the vegetable worlds, for instance, the zoospores of the algæ, which have the power of motion. Then the antherozoids, particularly the œdogonium, studied by Pringsheim, manifest the faculty not only of motion in general, but even of motion toward a definite object—in other words, show all the appearances of voluntary movement. As instances of mobility in plants, the author further cites the movements of the stamina of the *Berberis* (barberry), the *Drosera*, the *Dionæa muscipula* (fly-catcher), and the oscillating sainfoin (*Hedysarum gyrans*).

Sensibility too is found in several plants. The *Mimosa pudica* (sensitive-plant) is the most prominent instance of this. This plant reacts against any irritation by folding up its leaves, which again are spread out soon after the exciting cause is removed. It is a curious circumstance that most of the agents which excite sensibility in animals have a like effect on the mimosa: thus it is affected by sudden shock, by burning, by the action of caustic, by electrical discharges, etc. Nay, the same agents, such as chloroform and ether, which deaden sensibility, or assuage pain in animals, destroy the mimosa's power of reaction. Vegetal anæsthesia is produced by the same means as animal anæsthesia.

There are other plants besides the *Mimosa pudica* which manifest this curious property of reacting against irritation, for instance, the leguminosæ of the genera *Smithia*, æschynomene, desmanthus, *Robinia pseudacacia*, and the *Oxalis sensitiva* of India. From all this it follows that the power of movement and sensibility are functional properties which cannot strictly serve as a distinction between the vegetable and animal worlds.

Is Sex determined by Nutrition?—Mr. Thomas Meehan exhibited to the Philadelphia Academy of Natural Sciences specimens of the *Juglans nigra* (black walnut), with a view to showing that sex in plants is the result of the grade of nutrition, the highest grades of nutrition or vitality producing the female sex, and the lower grades the male. Examining a black-walnut tree at the flowering season, even the superficial observer will perceive three grades of growing buds. The largest buds make the most vigorous shoots. These seem to be wholly devoted to the increase of the woody system of the tree. Lower down the strong last-year shoots are buds not quite so large. These make shoots less vigorous than the other class, and bear female flowers on their apices. Below these are seen numerous small, weak buds, which either do not push into growth at all, or, when they do, bear simply the male catkins. As some naturalists hold that the feeble condition of these lower shoots is the *result* of their bearing male flowers, Mr. Meehan invited attention to the specimens themselves as conclusively proving the contrary. He was fully satisfied that any one, who would go out into the woods and fields for facts fresh from Nature, would see that there is not so great expenditure of vital force in the production of male flowers as there is in that of female flowers, and thus all he had advanced on this subject was fully sustained.

It will be remembered that, in our June number, we recounted the observations of Mrs. Mary Treat on the subject of controlling sex in butterflies, from which it appeared that butterfly-larvæ developed into male or female butterflies according as they were stinted in food, or liberally supplied with it. Besides the very interesting observations of Mr. Meehan, we have now further confirmation of Mrs. Treat's results in a paper communicated to the Philadelphia Academy by Mr. Gentry. The latter author, in the sum-

mer of 1871, had confined the larvæ of various species of moths, and neglected to supply them with food for four or five days. These larvæ had advanced toward their final change, possibly within a week or ten days. When the box was opened, the greater number were found in cocoons, while the remainder wandered about, as if in quest of food. The latter the author removed to another box, where they were provided with abundance of food. After three or four days they began to assume the chrysalis form. The first batch proved to be males without exception, while the last batch proved, with but two exceptions, to be females. (The whole number in the two batches was about sixty.)

Mr. Gentry then details further experiments made by him to decide this question, and states that the result was always the same. He adds the following facts, which came under his notice in the course of his observations and experiments: 1. That males are the invariable result when the larvæ are fed on diseased or innutritious food; 2. That in the fall, when the leaves have not their usual amount of sap, males are generally produced; 3. That more males are produced late in the season than females; 4. That the sexes, in early life, cannot be distinguished, the change being brought about, late in life, by the conditions of nutrition.

Intensity and Patience required in Scientific Work.—Whether in original work or in elaborating work already done, scientific labor, when conscientiously performed, is necessarily slow and exhausting. M. de Candolle, the great French botanist, has recently brought to a conclusion, with the seventeenth volume, his great "Prodrome of Plants," stopping at the completion simply of the *Dicotyledones*. It was begun by his illustrious father, Augustin Pyramus de Candolle, about 1816, who worked at it until his decease, in 1841. It was continued by his son Alphonse, who called to his aid other famous botanists, his son Casimir among them. With true *naïveté* the author pleads necessity of stopping at the point now reached—"*ne tertiam botanicorum generationem occideret!*"—lest the undertaking should kill off a third generation of botanists. In a supplemental pamphlet he gives his opinion that the Phanerogams, estimated at 110,000 species, might, by distributing the task among twenty-five botanists, be worked up in about fifteen or sixteen years. He says that in his father's time one could elaborate at the rate of ten species a day, but that now a faithful monographer (or specialist), under the modern requirements, can seldom exceed 300 or 400 species per annum—that is, about one species a day!

Rationale of Double Flowers.—That the tendency in plants to produce double flowers is a natural one, and not exclusively evoked by the florist, is shown by Mr. Thomas Meehan, in a communication to the Philadelphia Academy of Natural Sciences. Many of the commonest wild flowers, which no one would think of cultivating, have double flowers in cultivation, which were no doubt originally found wild; for instance, various species of ranunculus. The author had himself placed on record the discovery, wild on the Wissahickon, of a double *Saxifraga Virginica*, and Dr. James Darrach had found in the same location a double-trailing arbutus. There are in plants two methods by which double flowers are produced. The axis of a flower is simply a branch very much retarded in its development, and generally there are, on this arrested branch, many nodes between the series forming the calyx, or corolla, and the regular stamens and carpels, which nodes are entirely suppressed. But, when a double flower is produced, sometimes these usually suppressed nodes become developed, in which case there is a great increase in the number of petals, without any disturbance in the staminal characters. But, at other times, there is no disturbance of the normal character of the axis. This was the case with the trailing arbutus discovered by Dr. Darrach.

Land-Plants in Lower Silurian.—It has hitherto been supposed that the Silurian age was one in which an absolutely unbroken ocean enveloped the earth. Dr. Dawson made it probable that land-plants existed in the Upper Silurian, or latter Silurian age. Leo Lesquereux, in *American*

Journal of Science and the Arts, has well-nigh demonstrated that dry land existed in the Lower Silurian age. He communicates the discovery of two small specimens representing branches or small stems of a species referable to *Sigillaria*, and found on Long-street Creek, near Lebanon, Ohio, in clay-beds positively referable to the Cincinnati group of the Lower Silurian. With the exception of these Lebanon specimens, the geological formations of the United States have not afforded as yet any records of plants earlier than those of the Lower Devonian.

The Uses of Bees' Wings.—At the late Convention of Bee-Keepers at Louisville, D. L. Adair read an essay on the various uses of the bee's wings, in which he holds that, besides flying, the wing of the bee serves two or three other important ends. The horny frame, upon which the fine membrane of the wings is stretched, is composed of hollow tubes of a hard substance called *chitine*. These tubes are double, being one tube inside of another. The inner ones are extensions of the *tracheæ*, through which the air circulates in breathing; between this and the other tube is a space through which the blood circulates. The blood is brought in contact with the air through the thin walls of the air-tubes, just as the air and blood are brought together in the human lungs, and with the same effect.

The nervous filaments in like manner pass to the wings; they follow the respiratory tubes and all the fine venations of the wing, terminating in every part of its surface in papillæ, which in all animals are the vehicles through which sensations are perceived. Hence we may infer that the wings are the organs of some sensation. Are these nerve-filaments intended merely for noting tactile sensations? Mr. Adair is of the opinion that by means of them the bee is made conscious of odors. "Some naturalists have suggested the antennæ as the organs of smell; but, as they appear to be poorly adapted to perform such an office, it is just about as likely that they smell with them as that they see with them. Invisible particles emanating from odorous bodies, coming in contact with the olfactory nerves, produce the sense of smell. These atoms are mixed with and floating in the air, and, in order to collect them, a considerable volume of air must be made to pass over their surfaces—a thing which the wings certainly accomplish in an eminent degree."

The sense of hearing in bees has never been localized by naturalists, though some have supposed that the antennæ are the organs of this sense also. "What appendage of the bee," asks Mr. Adair, "would be better suited to receive sound-vibrations than the thin, stiff membranes composing the wings?"

The Lignite-Beds of the Rocky Mountains.—The opinion having been advanced that the so-called lignite-beds of the Rocky Mountains have been formed by the heaping of drifted materials, and not by growth *in situ*, Mr. L. Lesquereux replies as follows, in *Silliman's Journal*, to one of the arguments urged in favor of the opinion—viz., that the *under-clays* of the lignite-beds have no roots: "I can say," he writes, "from repeated and personal observations, that most of the lignite-beds of the West, which have passed under my examination, have the under-clays full of rootlets or of roots of the floating plants, which were the first, generally at least, to contribute to the formation of the bed of combustible material by their *débris*. At the Raton Mountains, at Cañon City, at Gehrung's, near Colorado, at Golden, Marshall, Black Butte, etc., the coal is everywhere underlaid by chocolate-colored shale, often a compound of these roots or rootlets, so compact, indeed, that they cannot be determined, nor their forms distinctly recognized. Of course, the under-shales do not contain any roots (true roots of trees); the coal of the carboniferous, too, never has any, for the good reason that trees do not grow in water, and that they only invade peat-bogs when the ground is solid enough to support them. And even then the roots grow horizontally, and do not descend deep into the matter which, generally impregnated by water, is to a degree inaccessible to atmospheric influence.

The so-called roots of the clay-beds of the carboniferous measures, or the *Stigmaria*, are not roots, but floating leaves. And even their cylindrical stems are rarely

found in clay-beds; only their leaves fill them just as the radicles of water-plants fill the clay of the Tertiary lignite. It is, however, a fact that some of the lignite clay-beds, and those of the coal-measures, too, are clean or without admixture of vegetable remains, even of rootlets. But when the peat is beginning its growth at the surface of a somewhat deep basin of water, whose bottom has been rendered impermeable by the deposit of clay (which always precedes the deposit of woody materials), this surface-peat is often thick and compact before it is forced down and comes in contact with the clay; and, in that case, therefore, the clay is pure, or is not penetrated by roots or rootlets. There are, of course, some beds of impure lignite, whose origin is due to drifted wood, especially along large rivers. One is known at the mouth of the Rhone, in France. I have seen some deposits of the kind in Southeastern Arkansas, near the Wachita River. The great Red-River obstructions may become in time lignite-deposits. But all formations of this kind show their origin by their composition, viz., sand mixed with carbonized matter, sandy bottom, perforated, too, in various directions by drifted stems, etc. Nothing of this kind has been observed in the beds of lignite of the West, at least not in those which have come under my examination."

Geology of the Land of Moab.—Late explorations in the land of Moab by Dr. Tristam have disclosed some interesting geological features in that region. The doctor's observations were mainly confined to the highlands, which are in reality a set of terraces, or table-lands, rising to the eastward from the shores of the Dead Sea—attaining, in a distance of 35 miles, a height of between 4,000 and 5,000 feet. These table-lands are cut at right angles into deep gorges or ravines, by streams which now flow, or at some former time have flowed, westward into the Dead Sea. Some of the gorges are 1,800 feet deep, with perpendicular walls, from which a good idea of the geological structure of the region may be obtained. The surface of these highlands is composed of chalk, which rests upon a limestone formation, regarded by some as nummulitic and by others as Jurassic. The chalk and limestone together are from 1,200 to 1,500 feet thick. The limestone is supported by new red sandstone, the line where they join being well defined. It is from this line of junction that the hot springs, so celebrated in Roman times, gush forth. The water of these springs has a temperature varying from 100° to 143° Fahr. The salt-hills at the south of the Dead Sea, like the table-lands just spoken of, have been gouged out by the action of water, and present along their face numerous columns and pinnacles of salt, that are being rapidly worn down by the action of the weather.

Etiology of Typhoid Fever.—Prof. I. Buckman writes to the *Gardener's Chronicle* concerning the discovery of a microscopic fungus in water, the drinking of which was suspected of developing cases of typhoid fever. We give the main points of this communication. Some years ago Prof. Buckman examined the spout of a pump which had supplied water to a family attacked by typhoid. It was found to be lined with gelatinous matter. Under the microscope this substance was seen to contain some elegant branched confervoid or fungoid growths, intermixed with which were minute ovoid cells. As these fungoids require nitrogen for their nourishment, the author inferred that the supply came from some neighboring cesspool. He next went to the exit-drain of the town sewerage, and there found bits of sticks, leaves of water-plants, and the like, more or less covered with this same gelatinous matter.

The author next detected this fungus in water used by his own family, some of whose members were severely attacked with typhoid fever. A defective drain in the neighborhood of the dwelling having been set to rights, and the whole of the water pumped out, the water has since been of excellent purity. Having cited two other analogous cases, Prof. Buckman speculates as follows on the mode in which this fungus acts after having been admitted into the animal economy: "How it acts it would be difficult to determine, but it is at least conceivable that the spores of the fungus may get into the circulation, and bring about changes in the fluids, after the manner of

yeast in beer; and, if so, the seeds of the fungus would be likely to develop rapidly, if they came in contact with milk, or water containing nitrogenous matter. 'A little leaven would leaven the whole lump,' and, as it appears to me, in this way much disease may be accounted for. The microscope, then, will enable us to make out the presence or absence of this fungoid or confervoid matter in foul water, and my own observations confirm me in the view that, being present, it is highly dangerous, and, if its cause can be removed, and the water made pure, all danger from this source at once ceases, while if it cannot it should be at once disused, and pure water be sought for elsewhere."

A Sun-driven Engine.—G. A. Bergh, writing in Poggendorff's *Annalen*, on the application of solar heat as a motive power, says that the engine which is to serve for this purpose must employ some liquid with a very low boiling-point. There are several such liquids — sulphurous acid, methylic chloride, methylic ether, etc. Of all of these, sulphurous acid best deserves attention, as it has several useful properties for the end in view. It is not too difficult to condense, and it can be got at a moderate price. Now we have got the principle on which we must construct our solar engine. Conceive a vessel, filled with sulphurous acid, exposed to the sun's rays; the tension of the sulphurous-acid vapor, if the temperature of this vessel *A* exceeds that of the surrounding air by at least 10° to 20°, must be from one to three atmospheres higher than that of the sulphurous-acid vapor in another vessel, *B*, similarly filled with sulphurous acid, but which has only the temperature of the surrounding air. We can thus arrange an engine which agrees in principle with the steam-engine, with merely this difference, that the water is replaced by sulphurous acid, and the fuel by the solar heat; while the vessel exposed to the sun's rays represents the steam-boiler, the vessel kept at ordinary temperature may represent the condenser. The sulphurous acid condensed, after doing work in the vessel *B*, could easily be driven back, by a force-pump, into the vessel *A*. The capability of work of such a machine must naturally increase with the amount of heat communicated to vessel *A* or be proportional to the surface exposed to the solar rays.

An establishment, furnished with a machine like this, might carry on its work while there was sunshine, but, in default of this, would be brought to a stand-still. True, the solar heat might be replaced by the heat of the air, if the temperature of the air were pretty high, and one had at hand a refrigerating substance like ice. But, as this is not always the case, the establishment should have, besides the sun-machine, an apparatus which might "store up" some of the work done by this. As such, Natterer's apparatus for condensing carbonic acid might be used. If a supply of carbonic acid were kept in a large gasometer, the Natterer apparatus might be fed from this. In a wrought-iron vessel, thus filled with liquid carbonic acid, we should thus have an enormous store of mechanical force, which might be made to replace the action of solar heat in the sun-machine, partially or wholly. After work done, the carbonic acid, become gaseous again, might be collected in the gasometer. Or, again, the sun-machine, while in action, might drive an ice-machine, and might, in default of sunshine, profit by the ice it had produced, for maintenance of its working.

The Movements of Drosera.—Prof. Asa Gray, commenting in the *American Journal of Science* on a paper by A. W. Bennett, on the movements of the glands of *Drosera* (*sundew*), remarks that the author's description of these movements does not do justice to the facts, as observed by Dr. Gray himself. Mr. Bennett observed not only the bending in of the glands upon the body of the insect which lights on its leaf, but that "the sides of the leaf had also slightly curved forward, so as to render the leaf more concave." With us, says Dr. Gray, the leaves do much more than that. As well in *Drosera rotundifolia* as in *D. longifolia*, the end of the leaf folds over upon the base, or nearly like a shut hand, thus fairly inclosing the captive insect.

He adds that, when Mrs. Treat's account of this infolding of the leaf was published, in 1871, the discovery was thought to be new. But he has since found that the in-

folding of the leaf, as well as the intrusion of the glands, was discovered by Roth in 1779. The only real addition to our knowledge—this old knowledge, recently reproduced—is that contained in the latter part of Mr. Bennett's communication, which is to the effect that *Drosera* acts upon bits of raw meat just as upon a living insect, but is motionless toward inorganic bodies, and, in his experiments, to bits of wood and of worsted. In the published report of the communication no allusion is made to the history and record of all these discoveries, but Prof. Gray claims for Mr. Darwin the credit of having been the first to discover this difference of behavior of the drosera-leaf to different substances. He says that there are other still more curious observations and experiments of Darwin's upon *Drosera* and *Dionæa*, which it is hoped will soon be published.

Ocean-Steamships.—A writer in the *Evening Post* notes some of the principal shortcomings of the ocean-steamship of the period, and offers some practical suggestions as to the proper construction of a passenger-steamer. The ocean-steamer of to-day is simply a huge freight-boat. She is somewhat larger, and perhaps a trifle swifter, but certainly not any safer, than when she first crossed the Atlantic some thirty years ago. It would seem absurd if our railroads had no passenger-cars, and we had to travel about the country strapped on to the roof of a freight-car. Ocean-travel is quite as absurd, and even more dangerous, for our tier of state-rooms is strapped to the top of a heavy iron box, loaded with heavy freight, which, in the event of a sudden blow, goes to the bottom as if it were made of glass. According to the writer in the *Post*, the passenger-steamship should be of about the same length as at present, but broader and shallower, with lines adapted, not to carrying capacity, but to speed; the chief novelty, however, being that the entire hull, excepting the spaces required for engines and coal, would be filled up with very small air- and water-tight compartments or cells—enough to make the ship a gigantic life-preserver. All the state-rooms and quarters would be on the main-deck. The cellular construction of the vessel would add greatly to her strength, while her lightness would admit, at least in ordinary weather, of great speed, and her model would greatly diminish the rolling so provocative of sea-sickness.

As regards the question of expense, while the first cost and daily outlay would not exceed those of the present style of steamer, the passenger-steamer could make twice as many trips in the year, for she would not only be actually faster, but would save much time between voyages which is now spent in discharging and receiving cargo; for the same reason, after landing her passengers, she could start again in a day or two on another trip. Such a vessel might be disabled by collision, but it is hardly possible that she could be sunk by any form of accident that we are familiar with.

Tarantism.—Tarantism is the title given by physicians to an epidemic nervous disorder which prevailed in Italy, and more particularly in Apulia, during the middle ages. It was supposed to be caused by the bite of the tarantula, a species of spider found in Southern Europe, and very plentiful in the vicinity of the city of Taranto, whence it derives its name. The disorder, whether caused in the first instance by the bite of this spider or not, was capable of passing from subject to subject by a sort of sympathy, and thus the affection would spread to hundreds and thousands of the population, without distinction of sex or age. Analogous nervous diseases, known as St. Vitus's dance, or St. Guy's dance, prevailed in Germany, France, and England. A recent writer on "Mental Disease," W. A. F. Browne, gives the following account of these singular affections:

"In all these affections," says he, "which spread over great masses of the population, Teutonic and Celtic, children and octogenarians alike, there were observed wild and exuberant excitement, delusion, and antipathies, with uncontrollable impulses to run or leap, all such movements ultimately passing into dancing, which was generally aggravated, though sometimes mitigated, by music. These dancers were impelled sometimes by imitation, sometimes by fanatical exaltation, sometimes by terror and the fear

of being poisoned, and it was when under the latter emotion that harmony seems to have been most powerful and curative. Airs (*tarantelle*) have been preserved which were employed in arresting or moderating the frenzied rotations and leaps of those urged on by dread of the bite of the tarantula, and by other causes; and that some interference was required is evident, for, although large numbers of those affected recovered, many resisted all coercion, and danced themselves to death."

The tunes which were regarded as remedial are said to have been of peculiar character, and to have contained transitions from a quick to a slow measure, and to have passed gradually from a high to a low key. The sensibility to music was so great that, at the very first tones of their favorite melodies, the affected sprang up, shouting for joy, and danced on without intermission until they sank to the ground exhausted and almost lifeless. Although thus excitable, no external or audible music was requisite to suggest or sustain such movements. Apparently stimulated by some internal rhythm, the performers danced, sometimes with infuriated, but always with measured steps, wheeling hand-in-hand in circles, not merely from street to street, but from town to town, dropping down when exhausted, but having their places supplied by fresh recruits. When under this inspiration, the rudest of the victims exhibited gracefulness in dancing, and manifested displeasure when false notes were introduced into the music.

Utilization of Sewage.—The following facts, with regard to the utilization of the sewage of the city of Paris, are taken from the official returns: At Clichy, a bend of the Seine forms a sandy, level peninsula, of some 5,000 acres. The barrenness of this peninsula is proverbial, and hence it was on this land that a portion of the city sewage was first directed, with a view to put the utility of this kind of fertilization to the severest possible test. The preliminary works were begun in 1868, and completed in May, 1869. From that time between 5,000 and 6,000 cubic yards of the sewage have been raised daily by engines of 40-horse power and centrifugal pumps, and of this two-thirds were received into tanks for chemical manipulation, the remainder being applied to a piece of land 12 or 15 acres in extent. At the end of several months the results of this experiment upon a naturally poor soil were such that the neighboring farmers asked to be included in the benefits derived from the sewage. Owing to the extreme permeability of the soil, 20,000 cubic yards of sewage could be annually absorbed per acre, and the farmers obtained crops of 70,000 lbs. of cabbages, 60,000 lbs. of carrots, and 150,000 lbs. of turnips. All land suitable for irrigation rose in value. No evil effects on the health of the inhabitants could be detected, and a village sprang up around the works. A Parisian perfumer established his manufactory on the outskirts of the irrigated land, and obtained a supply of the sewage-water for his gardens of aromatic herbs, more especially of peppermint. It is worthy of note, in this place, that the finest mignonette of Covent-Garden Market, London, has long been grown from sewage-irrigated soil.

NOTES.

An Honor to Prof. Henry.—Prof. Joseph Henry, secretary of the Smithsonian Institution, has received from the French Government a superb porcelain vase, as a testimonial of his services as the United States representative of the commission on the international standard metre.—*Journal of the Telegraph.*

New Fossil Man.—In the *Revue Scientifique* for December, it is stated that a third skeleton of a troglodyte has been discovered by M. Rivière, in the caves of Mentone. This new skeleton, judging from the various and numerous implements by which it was surrounded, lived at an epoch far more remote than that assigned to the skeleton now in the Museum of Paris. The instruments of warfare and other objects found with it, though composed of flint and bone, are not polished. They are only sharpened, and, by their coarse execution, appear to belong to the palæolithic age. On the upper part of the skeleton was a large number of small shells, each pierced with a hole, which appeared to have formed a collar or bracelets. No pottery nor any bronze object was found.—*Lancet.*

In an article on "Furs and their Wearers," published in the December Popular Science Monthly, the fur-seal of Alaska and the sea-otter were inadvertently confounded. In a letter kindly calling atten-

tion to the error, Mr. F. M. King, of Whitestone, L. I., who has been on the spot and knows the two animals, points out a few of their characteristic differences. The sea-otter is rarely seen on land, but eats, sleeps, and is said even to bring forth its young in the water. It is provided with a tail, has legs with webbed feet, and handles its food with its fore-paws, and is in fact an *otter*. The fur-seal breeds on shore, and is captured mostly out of the water. It has neither legs nor paws, but flippers like all the other *seals*.

THE death of the great German anatomist, MAX SCHULTZE, is announced. He was in the prime of life, and had just experienced the satisfaction of seeing his laboratory at Bonn—the amplest and most elegantly-constructed in Europe—finished, under his direct supervision. His death is a great loss to biological science.

A WRITER in the *American Naturalist* suggests that one of the most important uses to which the Yellowstone National Park can be put is, "the preservation from extinction of at least the characteristic mammals and birds of the West, as far as they can be domiciled in this section."

A GERMAN engineer proposes to combine hard ingots, or blocks of steel, in the process of casting, with laminæ of soft steel or wrought-iron, in such a manner that the latter, in undergoing the rolling process, may assume an internal position, thus combining a certain amount of elasticity, ductility, and toughness, in the interior, with a hard exterior to withstand wear and abrasion.

A CEMETERY is now being searched at Luzarches, in the vicinity of Paris, where articles of the times of polished stone have been found. Hatchets, knives, scissors, arrow-points, and delicately-worked blades, made of flint, have been discovered; also awls of bone from various animals; and, on the remains of a female skeleton, a kind of medallion with two holes was seen, which probably formed part of a necklace. Several skulls have been examined by Dr. Broca, who will communicate the results of his investigations to the Anthropological Society of Paris.

IT is stated that, at the recent Scientific Congress at Rome, two Neapolitan physicians submitted to the meeting a liquid preparation for stopping instantaneously the flow of blood from wounds of every description. A commission of physicians have performed experiments with it in one of the Roman hospitals, and have reported on it as one of the happiest of recent discoveries, and as particularly serviceable on the field of battle.

A CURIOUS addition was lately made to the aquarium of the Paris Jardin d'Acclimatation, viz., a polyp of the Medusa kind. The day after its admission to the compartment assigned to it, all the other animals in the same tank were found to be dead. An analysis of the water showed the reason of this strange mortality — the polyp had changed the water to vinegar. The so-called vinegar-polyp has the power of producing in itself alcohol, which is soon transformed into vinegar; this, however grateful it may be to the polyp that produces it, is fatal to other aquatic creatures. The poisonous Medusa was at once removed from the basin and put in a tank by itself, where it will be permitted to carry on its cheap vinegar-manufacture as long as it pleases.

AN exhibition of appliances adapted to economize fuel is to be held in Manchester, England. The exhibition will comprise: 1. Appliances which may be adapted to existing furnaces, etc., whereby an actual saving is effected in the consumption of fuel. 2. Appliances which may be adapted to existing furnaces, etc., whereby waste heat is utilized. 3. New steam-generators and furnaces, boilers and engines, specially adapted for saving fuel, and appliances whereby waste products are utilized, the radiation of heat prevented, etc. A variety of similar apparatus for manufacturing, agricultural, and domestic purposes, will also be exhibited. The exhibition promises to be interesting and instructive.

AN institution of novel character was recently founded in France. The Villa Emilia, at Meudon, half-way between Paris and Versailles, was thrown open on January 1st, to explorers of any nationality, to young men who propose making scientific voyages, and to all who wish and are able to encourage them. The expenses of the institution are to be defrayed by an association. The property already embraces instruments and laboratories, scientific books, etc. Free courses and lessons will be given, and travelers may leave their collections there, to be kept till their return. Gifts of money will be made to those who may serve the society in certain specified ways. The association, "Cercle des Explorateurs," as it is called, will have its Gazette, giving news of explorers, and there will be two meetings, in spring and fall. Those wishing to join the society are desired to communicate with its originator, M. Méhédin, Meudon, Seine et-Oise.

DR. FERRIER has received a grant from the Royal Society, for the purpose of enabling him to pursue his investigations on the brains of monkeys, etc. The results of his researches will, in due time, be embodied in a paper which will be read before that society.

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MALAYO-POLYNESIAN RACES. *Sample Table of Spencer's Descriptive Sociology.*

Division I. SAVAGE RACES.

SANDWICH ISLANDERS.

INORGANIC ENVIRONMENT.

Climate.—Very equable and salubrious. Temp. ranges from 60° to 88° Fh. Usual daily variation 10°. Rain falls on about 40 days in the year; generally clear at other times.

Surface.—A group of thirteen islands with an estimated area of some 6,000 sq. miles. Volcanic; frequent eruptions destroying villages and plantations. Mountains sometimes rise to a great elevation, and generally barren. Valleys fertile. Few navigable rivers; water scarce. Few good harbours. No valuable or useful metals.

ORGANIC ENVIRONMENT.

Vegetal.—Less valuable and abundant than in the Southern Islands. Taro, sweet-potatoes, and yams. Also bread-fruit, cocoa-nuts, plantains, sugar-cane, a species of *eugenia*; strawberries and raspberries.

Animal.—Few. Quadrupeds—hogs, and dogs, also an animal between a mouse and a rat. Good many birds; some of them furnishing feathers for decoration. Fish tolerably abundant. No beasts of prey, and none more ferocious than the wild hog. Entirely free from every noxious and poisonous animal, excepting centipedes.

SOCIOLOGICAL ENVIRONMENT.

No adjacent foreign races: but natives of different islands, or different sections of same island, frequently in a state of mutual hostility. Population estimated at between 100,000 and 200,000.

PHYSICAL CHARACTERS.

Rather above the middle stature; well-formed, with fine muscular limbs; open countenance, and features frequently resembling those of Europeans. Gait graceful, sometimes stately. Hair black, or brown, strong, often curly. Complexion olive, sometimes reddish-brown.
Ruling classes physically more powerful.

Good dispo

STRUCTURAL.

OPERATIVE.

OPERATIVE

Partial subdivision of labour, in addition to that between the sexes.

Men.—Occupations mainly out-door and laborious; subdivided

—Among the superior classes into house-carpenters, canoe-builders, farmers, fishermen.

—Inferior class mainly labourers, working on the soil.

Women.—Superior class; occupations mainly in-door and comparatively light.

—Inferior class; labour on land.

Local differentiation of occupations—farmers, fishermen. Some districts famous for manufacture of mats and cloth; others for various kinds of food.

REGULATIVE

Industrial government little separated from Political. Chiefs direct most commercial transactions, and impose taxes and tolls. Middle artizan class, receive wages. Lower class in state of serfdom, attached to the soil. Slave-class, male & female, labour on the land for the benefit of their conquerors.

REGULATIVE.

POLITICAL.

Hereditary monarchy; with turbulent feudal chiefs, formerly independent kings. Occasional national deliberative meetings.

CIVIL. Law partially separated from Custom.

DOMESTIC.

MARITAL.

Near consanguineous marriages frequent in the royal family.

Contract generally made by parents of both parties, or by man and parents of woman.

Polygamy allowed in all ranks, but practised only by chiefs.

Divorce easily obtained.

FILIAL.

Kinship apparently through female.

The father has power of life and death over his children.

Chief may nominate his successor, but nomination must be confirmed by the king.

PUBLIC.

1. King, royal family, and prime minister.
2. Governors of the different islands, and chiefs of large divisions. (Many of them descendants of those who were independent kings in Cook's time, and before consolidation of the whole into one kingdom.)
3. Chiefs of districts or villages, and priests.
4. Labouring classes.

Evidence of the former existence of a number of independent governments, and of the common people maintaining their rights by arms.

Land owned by government, to which district and village chiefs pay rent. Chiefs either sublet the land, or cultivate it by means of serfs.

Diets of former kings become law. King and chiefs are the legislators; and have each a number of attendants who execute their orders.

Cities of Refuge for protection of offenders.

Justice administered either by retaliation on the part of the injured parties; or by an appeal to the chief, the governor, or the king.

MILITARY.

Partly separated from Civil; inferior chief sometimes commanding.

Army not a distinct class.

Herald sent round to the various districts before war to summon to arms, after war to announce peace.

Considerably organized. Each chief led his own men, and was subject to the commander-in-chief. Army generally drawn up according to a definite plan. Men armed on the principle of division of labour. Battles commonly a succession of partial engagements; but sometimes the whole army except the *reserve* was engaged at once. Women serve as porters and nurses.

Sham fights.

Stone fortifications.

ECCLESIASTICAL.

Ecclesiastical government only partially separated from Political — the king sometimes acting as high-priest.

Priests a distinct class. Office hereditary.

Medicine-men, generally priests and sorcerers. Receive a fee for their services.

Women occasionally have power to lay on or remove tabu.

Burial-places are also the temple, or pantheon; where the images of dead chiefs are worshipped. Games and ceremonies instituted in honour of departed and deified men.

Animal and human sacrifices; offerings of food, &c.; prayers and other propitiatory rites. Images of war-gods taken to battle with the army; and the slain offered to them.

Tabu, both general and particular, occasional and permanent. Imposed either by sending round the herald of the priest, or by affixing a mark to the thing tabued. Breaches of tabu punished by death.

Say grace.

PROFESSIONAL.

Medicine-men. Astrologers. Prophets.

Strolling players and musicians. Itinerant bards.

A sort of fencing-masters.

CEREMONIAL.

MUTILATIONS.

Tatooing. Loss of from one to four of front teeth, on the death of a chief.

FUNERAL RITES.

Funerals performed in secret. Body generally disposed of by burial (natural caves preferred), burning, or throwing into the sea. Inferior chiefs and priests buried in a horizontal posture; common people in a sitting posture.

Provisions buried with the body, and placed over the grave for some time daily. Part of a canoe sometimes placed near the grave.

Bones of distinguished persons separated from the flesh, and preserved with superstitious reverence.

Bodies (part or whole) sometimes thrown into volcanoes, or into the sea; in the belief that the departed would exert a beneficial influence on the god of those regions.

Burial-places of the great (morais) closely connected with religious worship.

Expressions of grief—Bodily mutilations of various kinds. Dirges. On chief's death there is a general outbreak into all sorts of lawless excesses — fighting, murder, debauchery.

LAWS OF INTERCOURSE.

Marks of distinction. — Feather cloaks, varying in size and colour with rank; corpulency; quantity of clothing.

Signs of respect to higher ranks.—Prostration, standing, the removal of all ornaments above the waist.

Owner of anything, when asked to whom it belongs, says "It is yours and mine."

Salutations between equals. — Touching noses; complimentary inquiries.

Guests carry away the remnants of the feast that has been provided for them.

HABITS AND CUSTOMS.

Kill a pig when ratifying peace.

Vaious games and amusements—Gambling, boxing, wrestling, playing at bovls, singing, dancing.

Simple marriage ceremony. Women do not eat with men.

REGULATIVE.

SENTIMENTS.

ÆSTHETIC.

Very cleanly in person and food.

Shown in appreciation of beauty of flowers, and in simple contrasts—appealing to the eye in simple but gay personal adornment, in cloth painted with considerable variety of colours and a great variety of mathematical patterns, and in staining on utensils.

A flat occiput considered beautiful.

Shown little in monotonous vocal music and simple percussive instrumental music.

Shown much more in simple dances, chiefly of a dramatic nature, of considerable variety, and supported with a wonderful degree of spirit and vivacity.

Shown also in epic songs; in laments, manifesting considerable poetic feeling; and in a variety of tales, chiefly mythological.

MORAL.

Women generally modest.

Strong desire for approbation shown in social usages. Chiefs remarkable for courtesy and refinement. Civil, friendly, and kind to each other and to strangers. Hospitable; yet in a less degree than Tahitians.

Family affection very strong; yet infanticide formerly prevailed to a fearful extent. Generally inclined to steal.

IDEAS.

SUPERSTITIONS.

Every person not meeting with a violent death supposed to be destroyed by an unpropitious deity (or by the effect of sorcery).

The future life supposed to resemble the present.

Kings and principal chiefs supposed to be descended from the gods; and become deified after death. (The morai—burial-place—also the temple.) Spirits of departed relatives regarded as tutelar agents. Relics of deified men worshipped; images made to commemorate them, and also worshipped; games and ceremonies in their honour.

Mythology resembles that of other Polynesians. Traditions refer to Night, or a chaotic state, the origin of the world, and even of the greater part of the gods. The gods form a hierarchy: each presides over some special class of natural phenomena; the volcanic deities being among the highest. They are of both sexes: some are in the form of a shark. They fight, have games and dances, and live much as the natives do. The volcanic deities are an immigrant race.

Vague notion of an active beneficent Power; but the gods are, for most part, actively maleficent.

KNOWLEDGE.

Decimal notation — forty being made the basis of calculation.

Quipus used in a form seemingly not inferior to that of the Peruvians.

Division of the year into months, with separate names (closely connected with religious worship); and into nights, also named.

Acquainted with the medicinal properties of a good many herbs and roots. In surgery less advanced than the Tahitians.

Medicinal herbs said to have been given by the gods, through a deified man.

LANGUAGE.

SPOKEN AND WRITTEN.

Alphabet consists of 17 letters — 5 vowels and 12 consonants.

Every word and syllable terminates with a vowel.

Monosyllables about 5 per cent. Disyllables about 42. Trisyllables about 20 per cent.

Reduplication of two syllables frequent.

Agglutinate.

Copious, and capable of expressing ideas with great force and precision.

Partly hieroglyphic; partly pictorial signs.

Straight lines, semicircles, concentric rings, with dots, rude imitations of men, &c., cut in the rocks by travellers, to indicate how far they had wandered, the direction they had taken, and the number of the party.

PROC

DISTRIBUTION.

Fairs formerly held at stated periods, each district bringing to market those articles for the production of which it was famous: chiefly either cloth and mats, or food.

EXCHANGE.

Barter. Bargain not considered binding till both parties had expressed themselves satisfied. An appointed referee.

Co fined hum labou

FUNCTI

MALAYO-POLYNESIAN RACES.

TAHITIANS.

INORGANIC ENVIRONMENT.

Climate.—Average height of thermometer in shade 74° Fh. Mild and healthy. Thunderstorms and hurricanes pretty frequent. Moderately moist.

Surface.—Comprises a group of islands, the largest of which (Tahiti) is 108 miles in circumference; surrounded by coral reefs. Mountainous and rocky; scenery rich and varied. Most of the mountains covered to summit with trees. Valleys well watered, and extremely fertile; affording an easy subsistence to natives.

ORGANIC ENVIRONMENT.

Vegetal.—Luxuriant. Great abundance of plants yielding food, and suitable for building, clothing, &c.; most, if not all, that are cultivated, growing in a wild state—bread-fruit, taro, yams, sweet-potatoes, arrow-root, plantains, bananas, sugar-canes. The several varieties of bread-fruit, and same variety in different parts of the island, ripen at different seasons; so that there are few months of the year when ripe food is not to be had.

Animal.—Comparatively few species. Quadrupeds—Swine, dogs, rats. Bats. Land-birds not numerous—Owls, paroquets, pigeons. Water-fowl more abundant. Turtles numerous. Abundance of fish, including sharks. Ants apparently the only troublesome animal.

SOCIOLOGICAL ENVIRONMENT.

Adjacent foreign tribes—other Polynesians; separated by partial barriers—ocean; partially civilized, and generally peaceful.

Adjacent tribes of same race, inhabiting different districts of the island, or neighbouring islands; frequently in a state of mutual hostility.

PHYSICAL CHARACTERS.

Generally above middle stature (especially the upper classes, whose physical characters at once distinguish them from the lower orders). Limbs well-formed. More distinguished by activity and endurance than strength. Graceful and stately in gait. Colour olive, bronze, or reddish brown. Hair shining black or dark brown. Countenance open and prepossessing. Facial angle approaching that of Europeans. Eyes seldom large, but full, bright, and jet black; cheek-bones not high; nose rectilinear or aquiline, with often a fulness about nostrils; mouth in general well-formed; teeth entire and white.
Beauty, especially among women, quickly fades.

Impulsiv so acute a painful, sou fectly uneas very fond and dance.

STRUCTURAL.

OPERATIVE.

OPERATIVE

Considerable division of labour in addition to that between the sexes.

Men. — Distinct occupations among the middle classes.

—House-carpenters, canoe-builders, farmers, fishermen.

Women.—Make bark cloth, weave mats.

Considerable division of labour in making a canoe — some laying down the keel and building the hull; some making and fixing the sails; some fastening the outriggers, or adding the ornaments.

The same more or less the case in house-building.

Local division of labour—Farmers, fishermen.

REGULATIVE

Industrial government very little separated from Political. Land of chiefs cultivated by serfs. Superior chiefs kept canoe-builders; inferior chiefs employed hired workmen. Chiefs combined for the erection of public buildings. Voluntary combinations of the people for baking an immense ovenful of bread-fruit.

REGULATIVE.

POLITICAL.

Hereditary monarchy; closely interwoven with religion. Actual influence over turbulent chiefs neither powerful nor permanent.

CIVIL. Law beginning to separate from Custom.

DOMESTIC.

MARITAL.

The father magistrate in his family.

Among upper classes marriage arranged generally by betrothment; among others by regular courtship.

Polygamy extensively practised. Among the higher chiefs it is rather a system of concubinage.

Divorce easily obtained. But among upper classes the relationship was nominally continued long after it had actually ceased.

FILIAL.

Rank hereditary. Land, &c., often devised by will.

Kinship through female in two highest ranks. Primogeniture the law of inheritance.

Eldest son entered on sovereignty, titles, authority or property of father, at birth; the father acting as regent or manager during the son's minority.

PUBLIC.

1. Royal family and nobility.
2. Landed proprietors, or gentry and farmers. (The most numerous and influential.)
3. Common people. (Including slaves acquired in war.)

Each rank subdivided into numerous classes.

Regal establishment, maintained by produce of hereditary royal estates, and by requirements, legal and arbitrary, made on the people.

Prime minister and a few chiefs act as advisers to the king. National assemblies held.

Power of chief supreme in his own district; and greater than that of the king over the whole.

Each chief magistrate in his own district; the king nominal magistrate of the whole.

Private property recognized between subjects, but all subordinated to the rights of the king.

Justice generally administered by the injured party; yet certain crimes were, by general consent, visited with definite punishment—banishment, seizure (for theft).

MILITARY.

Partially separated from Civil: inferior chief sometimes commanding.

Coextensive with adult male population.

Incipient standing army — a number of men famous for valour, strength, or address in war, generally in attendance on king or chief, and called "fighting-men."

Herald sent round to summon to arms.

Each chief must furnish his quota of men to the army, during war; and farmers must render military service when landlord requires it.

A reserve-corps in time of war.

Natural rocky fortresses improved by art.

Fleets.

Forces marshalled under the direction of the principal leader.

Military & naval reviews, with sham-fights.

ECCLESIASTICAL.

Only partially separated from Political; the king being sometimes high-priest; and highest sacerdotal dignities often possessed by a member of the royal family; priests were also chiefs.

Priests (who were generally also the doctors and sorcerers) a distinct class. Office hereditary in all its departments.

Belong to all ranks of society. Each priest officiates in the rank to which he belongs. Men perform the office for both sexes; but each sex has its own priests.

Temples, or oratories (marœs), used also as burial-places: they are national, local, or domestic.

Idols of the gods, and also of the departed; enveloped in sacred cloth.

Worship consisted of prayers, offerings (of everything valuable), sacrifices, human and others. Seasons of worship, stated and occasional.

Divination. Amulets.

Tabu extensively practised.

PROFESSIONAL.

Doctors and sorcerers (generally belonging to the priesthood).

Prophets formerly existed.

Areois, a sort of strolling theatrical company.

Public orators. Heralds. Bards.

CEREMONIAL.

Religious worship, conduct of affairs of state, and all social intercourse, characterized by ceremonious observances.

MUTILATIONS.

Tatooing; removal of hair from limbs; eradicating or shaving the beard; reducing the eyebrows. Circumcision.

Flatten the noses of children.

FUNERAL RITES.

Bodies of chiefs embalmed, clothed, and placed in a sitting posture on a bier, inside a small house, within the precincts of the marœ, or temple. Weapons of deceased placed near the body; and a small altar erected before it, on which were daily placed offerings of food, &c. If deceased was of high rank, a person (generally a priest) was appointed to wait on the corpse, and present food to its mouth several times daily. After decay of body, the bones were buried within the family temple, or (sometimes) on top of most inaccessible mountains.

Bodies of middle and lower classes buried in a sitting posture in shallow graves.

A sort of Irish wake held on occasion of a death — bodily laceration, wailing, fighting. Elegiac and biographical ballads, composed and sung.

A peculiar ceremony some weeks after death —a party going through the island, and beating every one they meet.

House and property of deceased tabued.

LAWS OF INTERCOURSE.

Concrete marks of distinction—The possession of superior physical characteristics; corpulency; long finger-nails; quantity of clothing; ceremonial dresses, and insignia of authority — fans, &c.; size and beauty of canoe, as well as the number of rowers; number of bales of cloth.

Chief often fed by attendants. Ranks among Areois denoted by differences in tatooing.

Marks of respect—Uncovering the body as low as the waist in presence of the king and in the neighbourhood of his residence; creeping on hands and knees, kneeling, or sitting cross-legged; kissing the hand; presentation of wreaths of one's hair.

Use adulatory language in speaking of the king, or anything belonging to him. Abstain from using his name in common conversation.

Salutations — Embracing; touching noses. Use green branch as a sign of peace.

HABITS AND CUSTOMS.

Evidence of former cannibalism.

Jaw-bones of enemies kept as trophies.

Many strange customs connected with the Areoi institution.

Feasts religious and secular, periodical and occasional; — at coronation of king, births, marriages, &c. King and queen give entertainments.

Various games; some of them of national importance, and resembling Olympic games.—Wrestling, boxing, foot-race, canoe-race; the men of one district challenging those of another. Cock-fights. Throwing the spear.

Several families often reside in one house. Generally two meals a day, forenoon & evening.

Women do not eat the same food as men. Everybody eats apart. Women wear their hair short; men generally wear it long.

REGULATIVE.

SENTIMENTS.

ÆSTHETIC.

Shown in remarkable personal cleanliness.

Shown in a love of flowers, and other beautiful natural objects, in personal adornment; and in the graceful imitations of natural objects in painting of their cloth. Shown less in carving, in which they do not excel. A flat nose considered a mark of beauty.

Shown in a love of music; which, however, is simple and rude.

Shown more in well-executed dances; and in dramatic entertainments, performed by itinerant theatrical parties.

Shown in songs sung by itinerant bards, &c., and of great variety.

In legendary and historical ballads.

Little or no sense of decency, in the intercourse of the sexes.

MORAL.

Sober. Chastity not a virtue; fathers and brothers prostituting the women of their family for gain.

Loyal. Very ceremonious. Considerable national vanity. Express great disgust at European custom of eating in society and in presence of women. Not remarkable for bravery.

Thieves; but not greater, if so great, as Englishmen in similar circumstances.

Theft not so much practised among themselves, and always considered as a crime.

Cruel to enemies; yet comparatively free from treachery or revenge. Exceedingly hospitable and generous.

Parental discipline lax. Parental and filial affection strong. Infanticide very prevalent, especially of female children: it is supposed that about two-thirds of the children were thus destroyed. Children of parents different in rank destroyed to preserve purity of rank.

IDEAS.

SUPERSTITIONS.

Spirits of departed appearing in dreams supposed to be the real person. The gods also appeared in dreams.

Vague ideas of death; food being daily presented to the dead body of superior persons, whose spirits revisit the earth.

Some spirits eaten by the gods, others deified. No belief in future punishments.

The heaven most familiar was situated near a mountain in Raiatea; but invisible to mortals.

Cosmogony resembled that of the Greeks. Origin of all things, gods included, attributed to Chaos or Night.

Gods form a hierarchy. Different gods presided over the different classes of natural phenomena; over different localities; over different professions; over wars, labours, and games.

Departed kings, chiefs, and relatives deified; and supposed at times to enter the images made in their honour, or to become embodied in birds, fishes, mountains, trees.

Gods mostly considered as malevolent. Every calamity attributed to them, in consequence either of some crime or of an offering made by an enemy.

KNOWLEDGE.

Decimal notation. No name for a number higher than *million*; but can easily count higher. Use in counting pieces of leaf-stalk; setting apart a short piece for each *ten*, and a longer for each *hundred*, &c.

Compute time, sometimes by generations; generally by years.

Year divided into 12 or 13 moons, and into seasons, or half-years; moons into 30 days; each day and moon having distinct names. Time reckoned by nights. Apparently no division between months and days.

Sagacious in foretelling the weather. Know the stars by names; as well as the times of appearing and disappearing; and steer by them.

Distance measured by time.

Doctors have considerable acquaintance with medicinal properties of herbs, and their adaptability to certain diseases. Considerable skill in dressing wounds, and in surgery.

Legendary and historical ballads are the authorities for disputed points in history.

LANGUAGE.

SPOKEN AND WRITTEN.

Ten consonantal sounds.

Abounds in vowel sounds.

Most syllables consist of a consonant and a vowel; both syllables and words always end with a vowel.

Monosyllables rare.

Agglutinate.

Characterized by copiousness, variety, precision, and purity.

A sacred dialect. A ceremonial dialect.

All proper names are significant. Cease to employ words forming part or whole of sovereign's name; and invent new terms. Words resumed on sovereign's death.

PROC

DISTRIBUTION.

Apparently not separate distributing agency.

Took yearly voyages to other islands for the purpose of exchanging cloth for bamboos filled with oil.

EXCHANGE.

Barter.

Hired workmen paid in pigs and cloth, in addition to receiving food.

Sociology.

SANDWICH ISLANDERS.

TABLE IX.

S.

IRONMENT.

undant than in the Southern yams. Also bread-fruit, cocoa- of *eugenia*; strawberries and

gs, and dogs, also an animal many birds; some of them fur- tolerably abundant. No beasts an the wild hog. Entirely free mal, except centipedes.

SOCIOLOGICAL ENVIRONMENT.

No adjacent foreign races: but natives of different islands, or different sections of same island, frequently in a state of mutual hostility. Population estimated at between 100,000 and 200,000.

PHYSICAL CHARACTERS.

Rather above the middle stature; well-formed, with fine muscular limbs; open countenance, and features frequently resembling those of Europeans. Gait graceful, sometimes stately. Hair black, or brown, strong, often curly. Complexion olive, sometimes reddish-brown.

Ruling classes physically more powerful.

EMOTIONAL CHARACTERS.

Good disposition; mild, docile, industrious.

INTELLECTUAL CHARACTERS.

Inquiring; fond of the marvellous; inventive as well as imitative; readily adopt the manners and customs of civilized life; show an aptitude for learning to read and write, and for commerce.

FUNCTIONAL.

E.

CEREMONIAL.

FUNERAL RITES.	LAWS OF INTERCOURSE.	HABITS AND CUSTOMS.
Funerals performed in cret. Body generally posed of by burial (na- ral caves preferred), rning, or throwing to the sea. Inferior iefs and priests buried a horizontal posture; mmon people in a ting posture. Provisions buried th the body, and ced over the grave some time daily. rt of a canoe some- es placed near the ve. Bones of distinguished rsons separated from flesh, and preserved h superstitious re- ence. Bodies (part or whole) metimes thrown into canoes, or into the ; in the belief that departed would rt a beneficial influ- on on the gods of se regions. Burial-places of the t (mornia) closely nected with religious ship. xpressions of grief— ily mutilations of ous kinds. Dirges. chief's death there general outbreak all sorts of lawless sses — fighting, der, debauchery.	Marks of distinction.—Feather cloaks, varying in size and colour with rank; corpulency; quantity of clothing. Signs of respect to higher ranks.—Prostration, standing, the removal of all ornaments above the waist. Owner of anything, when asked to whom it belongs, says "It is yours and mine." Salutations between equals. — Touching noses; complimentary inquiries. Guests carry away the remnants of the feast that has been provided for them.	Kill a pig when ratifying peace. Various games and amusements—Gambling, boxing, wrestling, playing at bowls, singing, dancing. Simple marriage ceremony. Women do not eat with men.

REGULATIVE.

SENTIMENTS.		IDEAS.		LANGUAGE.
ÆSTHETIC.	MORAL.	SUPERSTITIONS.	KNOWLEDGE.	SPOKEN AND WRITTEN.
Very cleanly in person and food. Shown in appreciation of beauty of flowers, and in simple contrasts—appealing to the eye in simple but gay personal adornment, in cloth painted with considerable variety of colours and a great variety of mathematical patterns, and in staining on utensils. A flat occiput considered beautiful. Shown little in monotonous vocal music and simple percussive instrumental music. Shown much more in simple dances, chiefly of a dramatic nature, of considerable variety, and supported with a wonderful degree of spirit and vivacity. Shown also in epic songs; in laments, manifesting considerable poetic feeling; and in a variety of tales, chiefly mythological.	Women generally modest. Strong desire for approbation shown in social usages. Chiefs remarkable for courtesy and refinement. Civil, friendly, and kind to each other and to strangers. Hospitable; yet in a less degree than Tahitians. Family affection very strong; yet infanticide formerly prevailed to a fearful extent. Generally inclined to steal.	Every person not meeting with a violent death supposed to be destroyed by an unpropitious deity (or by the effect of sorcery). The future life supposed to resemble the present. Kings and principal chiefs supposed to be descended from the gods; and become deified after death. (The morai—burial-place—also the temple.) Spirits of departed relatives regarded as tutelar agents. Relics of deified men worshipped; images made to commemorate them, and also worshipped; games and ceremonies in their honour. Mythology resembles that of other Polynesians. Traditions refer to Night, or a chaotic state, the origin of the world, and even of the greater part of the gods. The gods form a hierarchy: each presides over some special class of natural phenomena; the volcanic deities being among the highest. They are of both sexes: some are in the form of a shark. They fight, have games and dances, and live much as the natives do. The volcanic deities are an immigrant race. Vague notion of an active beneficent Power; but the gods are, for most part, actively maleficent.	Decimal notation—forty being made the basis of calculation. Quipus used in a form seemingly not inferior to that of the Peruvians. Division of the year into months, with separate names (closely connected with religious worship); and into nights, also named. Acquainted with the medicinal properties of a good many herbs and roots. In surgery less advanced than the Tahitians. Medicinal herbs said to have been given by the gods, through a deified man.	Alphabet consists of 17 letters—5 vowels and 12 consonants. Every word and syllable terminates with a vowel. Monosyllables about 5 per cent. Dissyllables about 42. Trisyllables about 20 per cent. Reduplication of two syllables frequent. Agglutinate. Copious, and capable of expressing ideas with great force and precision. Partly hieroglyphic; partly pictorial signs. Straight lines, semicircles, concentric rings, with dots, rude imitations of men, &c., cut in the rocks by travellers, to indicate how far they had wandered, the direction they had taken, and the number of the party.

OPERATIVE.

PROCESSES.					PRODUCTS.						
DISTRIBUTION.	EXCHANGE.	PRODUCTION.	ARTS.	REARING, ETC.	LAND-WORKS	HABITATIONS, ETC.	FOOD.	CLOTHING.	IMPLEMENTS.	WEAPONS.	ÆSTHETIC PRODUCTS
Fairs formerly held at stated periods, each district bringing to market those articles for the production of which it was famous; chiefly either cloth and mats, or food.	Barter. Bargain not considered binding till both parties had expressed themselves satisfied. An appointed referee.	Confined to human labour.	Cooking same as at Society Islands. Make intoxicating drinks from the *dracæna*, sweet potato, &c. Use nuts strung on a rush for light. Make cloth from bark, like Tahitians. Paint cloth by stamping it with a bamboo. Glaze it by rubbing it with a shell. Stain calabashes by drawing the figures with a stone or hard wood, steeping them in colouring mixture, and then baking them.	Domestic animals—Dogs, fowls. Cultivated plants—Taro, sweet-potato, yam, sugar-cane, &c. Plantations, with hedges. Gardens round the houses. Irrigation very extensively practised. Dig the soil by means of pointed sticks.	Crooked paths, a foot or more wide, from one village to another. Artificial fortifications built of stone. Aqueducts of stone, and clay. Artificial fish-ponds.	Permanent dwelling-houses, generally clustered in small towns or villages near the sea. Resemble externally the roof of a barn placed on the ground, and covered from top to bottom. Sometimes raised on posts. No windows. Floor covered with dry grass and mats. Mere huts for the poorer classes. Natural caves also used as dwelling-houses. Work-shops for building and repairing canoes.	Chiefly vegetable—Taro, bread-fruit, sweet potatoes, cocoa-nuts, &c. Hogs, dogs, &c.; eaten principally by chiefs. Fish. Salt plentiful, and used with food. Drinks—water, cocoa-nut milk, ava, and other intoxicating draughts.	Not cut or fitted to the body. A piece of cloth (sometimes rendered impervious by varnish) round the waist. The higher classes have also a large piece over their shoulders. Sleeping cloths (used by chiefs only). Cloth made from the Chinese paper-mulberry tree.	Spears, clubs, or halberds, wooden daggers, javelins, slings. Canoes, single and double, well-made, and highly finished; from 12 to 60 or 70 feet long. Mats, lines, fish-hooks, of hard wood and bone. Earthen pans, for evaporation of salt water. Gourd-shells for holding food and water. Sharp stick for digging.	Spears, clubs, or halberds, wooden daggers, javelins, slings. Wicker helmets.	Personal Adornment.—Feather-caps and cloaks. For women, necklaces or ruffs of coloured feathers, shells, or twisted hair. Bracelets of boar's tusks, or shells. Flower garlands. Decoration of Products.—Cloth scented and painted with various colours and a great variety of patterns. Carvings on instruments and weapons. Calabashes ornamented with rhomboids, stars, circles, &c. Dances.—Simple; accompanied with chanting or singing; dramatic, representing incidents in life of royal family, &c. Music.—Vocal: monotonous. Instrumental: drums; two sticks. Chiefly for beating time to the dances. Literature.—Epics, sung by regular bards, relating to achievements of kings, &c. Laments, invocations; tales, relating chiefly to giants, demigods, warriors, chiefs, &c. Songs.—Short metrical sentences, agreeing in accent and cadence at the end of each.

TAHITIANS.

TABLE X.

NMENT.

ace of plants yielding food, ; most, if not all, that are ad-fruit, taro, yams, sweet- sugar-canes. The several y in different parts of the there are few months of

Quadrupeds—Swine, dogs, —Owls, parroquets, pigeons. erous. Abundance of fish, nly troublesome animal.

SOCIOLOGICAL ENVIRONMENT.

Adjacent foreign tribes—other Polynesians; separated by partial barriers—ocean; partially civilized, and generally peaceful.

Adjacent tribes of same race, inhabiting different districts of the island, or neighbouring islands; frequently in a state of mutual hostility.

PHYSICAL CHARACTERS.

Generally above middle stature (especially the upper classes, whose physical characters at once distinguish them from the lower orders). Limbs well-formed. More distinguished by activity and endurance than strength. Graceful and stately in gait. Colour olive, bronze, or reddish brown. Hair shining black or dark brown. Countenance open and prepossessing. Facial angle approaching that of Europeans. Eyes seldom large, but full, bright, and jet black; cheek-bones not high; nose rectilinear or aquiline, with often a fulness about nostrils; mouth in general well-formed; teeth entire and white.

Beauty, especially among women, quickly fades.

EMOTIONAL CHARACTERS.

Impulsive; but emotions of short duration, and apparently not so acute as ours. Display of emotions, both pleasurable and painful, sometimes takes the form of bodily mutilations. Perfectly unembarrassed in address. Lively, good-natured, cheerful, very fond of laughter, jesting, humour and conversation, song and dance. Sympathetic, but merciless when roused.

INTELLECTUAL CHARACTERS.

Remarkably curious and inquisitive. Compared with other Polynesians, they are ingenious, and possess considerable mechanical invention and imitation. Desire and aptitude for learning to read, write, and count; as well as for adoption of foreign manners. A surprising amount of patient perseverance manifested by some of their manufactures.

FUNCTIONAL.

E.

CEREMONIAL.

ip, conduct of affairs of state, and all social intercourse, characterized by ceremonious observances.

NERAL RITES.	LAWS OF INTERCOURSE.	HABITS AND CUSTOMS.
ies of chiefs em- , clothed, and in a sitting posi- n a bier, inside a house, within the cts of the mare, ple. Weapons of ed placed near dy; and a small erected before it, hich were daily offerings of food. f deceased was of rank, a person ally a priest) was ted to wait on rpse, and present o its mouth seve- es daily. After of body, the were buried with- family temple, or imes) on top of naccessible moun- ies of middle and classes buried in ting posture in w graves. ort of Irish wake on occasion of a — bodily lacera- wailing, fighting. c and biographi- allads, composed ng. eculiar ceremony weeks after death rty going through and, and beating one they meet. se and property eased tabued.	Concrete marks of distinction—The possession of superior physical characteristics; corpulency; long finger-nails; quantity of clothing; ceremonial dresses, and insignia of authority — fans, &c.; size and beauty of canoe, as well as the number of rowers; number of bales of cloth. Chief often fed by attendants. Ranks among Areois denoted by differences in tatooing. Marks of respect—Uncovering the body as low as the waist in presence of the king and in the neighbourhood of his residence; creeping on hands and knees, kneeling, or sitting cross-legged; kissing the hand; presentation of wreaths of one's hair. Use adulatory language in speaking of the king, or anything belonging to him. Abstain from using his name in common conversation. Salutations — Embracing; touching noses. Use green branch as a sign of peace.	Evidence of former cannibalism. Jaw-bones of enemies kept as trophies. Many strange customs connected with the Areoi institution. Feasts religious and secular, periodical and occasional;—at coronation of king, births, marriages, &c. King and queen give entertainments. Various games; some of them of national importance, and resembling Olympic games.—Wrestling, boxing, foot-race, canoe-race; the men of one district challenging those of another. Cock-fights. Throwing the spear. Several families often reside in one house. Generally two meals a day, forenoon & evening. Women do not eat the same food as men. Everybody eats apart. Women wear their hair short; men generally wear it long.

REGULATIVE.

SENTIMENTS.		IDEAS.		LANGUAGE.
ÆSTHETIC.	MORAL.	SUPERSTITIONS.	KNOWLEDGE.	SPOKEN AND WRITTEN.
Shown in remarkable personal cleanliness. Shown in a love of flowers, and other beautiful natural objects, in personal adornment; and in the graceful imitations of natural objects in painting of their cloth. Shown less in carving, in which they do not excel. A flat nose considered a mark of beauty. Shown in a love of music; which, however, is simple and rude. Shown more in well-executed dances; and in dramatic entertainments, performed by itinerant theatrical parties. Shown in songs sung by itinerant bards, &c., and of great variety. In legendary and historical ballads. Little or no sense of decency, in the intercourse of the sexes.	Sober. Chastity not a virtue; fathers and brothers prostituting the women of their family for gain. Loyal. Very ceremonious. Considerable national vanity. Express great disgust at European custom of eating in society and in presence of women. Not remarkable for bravery. Thieves; but not greater, if so great, as Englishmen in similar circumstances. Theft not so much practised among themselves, and always considered as a crime. Cruel to enemies; yet comparatively free from treachery or revenge. Exceedingly hospitable and generous. Parental discipline lax. Parental and filial affection strong. Infanticide very prevalent, especially of female children: it is supposed that about two-thirds of the children were thus destroyed. Children of parents different in rank destroyed to preserve purity of rank.	Spirits of departed appearing in dreams supposed to be the real person. The gods also appeared in dreams. Vague ideas of death; food being daily presented to the dead body of superior persons, whose spirits revisit the earth. Some spirits eaten by the gods, others deified. No belief in future punishments. The heaven most familiar was situated near a mountain in Raiatea; but invisible to mortals. Cosmogony resembled that of the Greeks. Origin of all things, gods included, attributed to Chaos or Night. Gods form a hierarchy. Different gods presided over the different classes of natural phenomena; over different localities; over different professions; over wars, labours, and games. Departed kings, chiefs, and relatives deified; and supposed at times to enter the images made in their honour, or to become embodied in birds, fishes, mountains, trees. Gods mostly considered as malevolent. Every calamity attributed to them, in consequence either of some crime or of an offering made by an enemy.	Decimal notation. No name for a number higher than *million*; but can easily count higher. Use in counting pieces of leaf-stalk; setting apart a short piece for each *ten*, and a longer for each *hundred*, &c. Compute time, sometimes by generations; generally by years. Year divided into 12 or 13 moons, and into seasons, or half-years; moons into 30 days; each day and moon having distinct names. Time reckoned by nights. Apparently no division between months and days. Sagacious in foretelling the weather. Know the stars by names; as well as the times of appearing and disappearing; and steer by them. Distance measured by time. Doctors have considerable acquaintance with medicinal properties of herbs, and their adaptability to certain diseases. Considerable skill in dressing wounds, and in surgery. Legendary and historical ballads are the authorities for disputed points in history.	Ten consonantal sounds. Abounds in vowel sounds. Most syllables consist of a consonant and a vowel; both syllables and words always end with a vowel. Monosyllables rare. Agglutinate. Characterized by copiousness, variety, precision, and purity. A sacred dialect. A ceremonial dialect. All proper names are significant. Cease to employ words forming part or whole of sovereign's name; and invent new terms. Words resumed on sovereign's death.

OPERATIVE.

PROCESSES.					PRODUCTS.						
DISTRIBUTION.	EXCHANGE.	PRODUCTION.	ARTS.	REARING, ETC.	LAND-WORKS.	HABITATIONS, ETC.	FOOD.	CLOTHING.	IMPLEMENTS.	WEAPONS.	ÆSTHETIC PRODUCTS
Apparently no separate distributing agency. Took yearly voyages to other islands for the purpose of exchanging cloth for bamboos filled with oil.	Barter. Hired workmen paid in pigs and cloth, in addition to receiving food.	Confined to human labour.	Prepare several excellent made-dishes. Cook by baking or boiling. Distillation taught by Sandwich Islanders. Make ava. Preserve bread-fruit by fermenting it. Use artificial light. Cloth sometimes painted by pressing upon it ferns and flowers previously dipped in colouring matter Mats all woven by the hand. Hollow out canoes by burning, or by the adze.	Domestic animals.—Pigs, dogs, and fowls. Cultivated plants—Bread-fruit, yams, taro, sweet-potato, arrow-root, plantains, &c. Inclosed plantations and gardens. Trees planted in rows. Irrigation practised.	Rocky fortresses improved by art, as places of defence. Channels cut for purposes of irrigation. Terraces on hillsides, for cultivation of yams. Fences round plantations and gardens.	Permanent dwelling-houses, of an oblong or oval shape; consist of a frame-work of wood, thatched with palm-leaves; the eaves project; sides frequently left open. Dimensions from 15 to 20 ft. long, and 10 to 15 ft. wide; roof 8 or 9 ft. high in the middle, and 5 or 6 at sides. Contain but one room. Houses of leading chiefs capable of containing 2,000 or 3,000 people. Houses erected either within the plantations, on the shore, or by the wayside. Those of respectable classes surrounded by an inclosed court, sometimes covered with dry grass, but more frequently paved with pebbles or coral. (Floor of houses either paved or covered with mats and grass.) Large public buildings in each district, chiefly for amusement; maintained at public expense. Temples, or oratories, national, local, and domestic.	Animal.—Pigs, dogs, domestic fowls, wild ducks, pigeons, aquatic birds; fish—albicore, bonito, ray, sword-fish, shark, rock-fish, prawns, eels, shell-fish; turtle. Vegetal.—Bread-fruit, taro, yams, sweet-potato, arrow-root, fern-root, cocoa-nut, plantain, banana, plums, chestnuts, jambo, ti-root, sugar-cane.	The *maro*, a broad girdle passing round the waist. The *pareu*, reaching from waist to calf of leg. The *tipeta*, having a hole in the centre through which the head is passed, and hanging over the shoulders, breast, and back; exactly resembles the *poncho* of South Americans. The *maro* or *pareu*, and the *tipeta*, the most generally worn. Several scarfs or shawls: one of them resembling Roman *togæ*. Bonnets or shades of cocoa-nut leaves.	Canoes, various in size and shape, single and double. Shell and bamboo knives; bone (generally human) chisel; stone and wooden adzes; coral rasp; skin of sting-ray, with sand, for polishing; shark's tooth, for shaving; two shells acting as scissors. Fishing implements:—Spears; nets, various in kind and size; cord and lines; wooden, shell, and bone hooks. Bow and arrows. Cocoa-nut shells, for holding water, and for drinking cups; baskets and matting; sieves of cocoa-nut husk; wooden dishes; wooden mortar and stone pestle. Wooden stool (occasional), wooden pillows; low bed-stead (occasional). Comb, made of strips of bamboo fastened together; mirror—cocoa-nut shell filled with water.	Double war-canoes, 60 ft. long, furnished with a platform, and holding 50 fighting men. Spear; club; *pacho*, a sort of club armed with shark's teeth; a kind of short sword, with from 3 to 5 blades; backbone of sting-ray; slings and stones; stones. Helmet of cloth or cane-work. A sort of coat-of-mail of net-work.	Bodies tatooed in stars, circles, lozenges, tree-patterns, &c.; wigs; scented hair-oil; wreaths and necklaces of flowers; feathers; pearls and shells suspended from the ear by braided human hair. Dishes carved — in stars, zigzag lines, and polished. Carving and painting on canoes, houses, &c. Uncouth figures of men and beasts in temples. Dances. — Movements generally slow; but remarkably regular and exact; usually accompanied by music. Generally dramatic, conducted by itinerant theatrical parties. Dramatic war-dances. Music. — Rude. Vocal: extends to 3 or 4 notes. Instrumental: percussive. Drum, a hollowed block covered with skin. A joint of bamboo, beaten with a stick. Shell-trumpet: sound monotonous and dismal. Flute, with 4 or 5 holes; blown from nostrils. Literature.—Songs adapted to every department of society, period of life, and occupation. Legendary and historical ballads.

Sample Table of Spencer's Descriptive Sociology.

Division II. Decayed Civilizations.

ANCIENT PERUVIANS.

INORGANIC ENVIRONMENT.

Three quite different parts of the country:

1. *Coast Region:* Sandy waste, with insulated river valleys of high fertility. Red sandstone, granite, porphyry. Rainless region extending to about 7,000 ft. above level of the sea. Mean annual temperature, 72°. Frequent earthquakes.

2. The *Sierra:* South of 11° South latitude, two inclined plains rising to 13–14,000 feet; northwards, two valleys sloping rapidly. Trachite, augite, diorite, granite, and porphyry. In the wet season (November to May) weather extremely variable, in the dry season sunny and cheerful by day and dry and frosty by night (30° or under).

3. The *Montaña:* To the east of the Andes. Plains traversed by low hills. Maximum 85°, minimum 74°.

ORGANIC ENVIRONMENT.

1. *Coast Region:* Vegetation only on the banks of the streams. Luxuriant when the sea vapours are densest (end of June). Most of tropical plants cultivable.

2. *Sierra:* In the northern low valleys all the intertropical plants and fruits. In the higher parts maize, fruit-trees, herbs in abundance. In the highest potatoes, &c.

3. *Montaña:* Immense vegetation of all kinds.

Fauna: puma, jaguar, bear, deer, llama, alpaca, guanaco, vicuña, wild boar, fox, alligator, tortoise, condor, myriads of sea-birds, &c.

SOCIOLOGICAL ENVIRONMENT.

Principal aboriginal natio[ns]: The *Yuncas* of the Coast are widely different from the inhabitan[ts] of the four Andes regions of Quitu, Chinchasuyu, the Centre (*Quichuas — Yncas? — Canas, Chanoas, Huancas, Rucanas*), the Colla[s]. Apparently no intercourse with foreign civilized races.

PHYSICA[L]

Quichuas: Short statu[re] chested; small hands and[d] Hair black. Little bear[d] chin; rather high cheek[-] brows. Forehead high, h[ead]

Collas: Shorter statur[e]

Population of the Coast very ancient (middings contemporaneous with the post-pleistocene fossil vicuña of Corocoro). A diminutive race, followed by the Yuncas, who in some valleys (Chimu, &c.) arrived at considerable civilization. Some traces of a previous civilization. In the Sierra there are no traces of an older civilization. After an inte[r]
Yncas, according to the native tradition f[rom] about A.D. 1000. Spanish Conquest from 151[3].

STRUCTURAL.

OPERATIVE.

OPERATIVE	REGULATIVE.
Some division of labour, beyond that between the sexes. Men and women co-operated in agriculture, and both carried loads. *Men* made shoes, wove fine cloth, spun cords, &c. *Women* performed household work, spun all wool and cotton for weaving, wove the coarser cloth, &c. Here and there the reverse observed (with the Cañaris by reason of scarcity of men ?). Every man was acquainted with the domestic handicrafts and the making of arms. Special artizans for special arts, and skilled workmen in the service of the Yncas, Curacas, and the temples, even for ordinary trades. *Mamacuna* wove fine cloth. Consequently some specialization. Crafts were hereditary. Each province furnished that produce for which it was best fitted by the skill of the inhabitants or abundance of raw materials. Hence local expertness in particular trades. By virtue of the wholesale transplantations of people (*mitimaes*), there was also transplantation of skilled labour. Silver and gold workers at Xauxa, weavers of the finest cloth at Capachica. Best *chicha* brewed in Guanape. Fine tapestry woven at Pomatambo, Caxamarca, &c. The best artizans assembled at Cuzco.	Industrial government identical with political. Labour inspected by government, being partly due as tribute (by the "common law"), partly spent in supporting neighbours (by the "brotherly law"), and, when private, as being supported by supply of raw materials, or, in years of scarcity, compensated by distributions from the stores. Idleness was a punishable offence. No paid labour. A class of slaves (?)

REGULATIVE.

POLITICAL.

The Ynca government, spreading, as it were, by continuous crusades from the province of Cuzco, and absorbing likewise the somewhat concentrated kingdoms in the Collao, in some Coast valleys, &c., and the scattered tribes, if possible by persuasion, if not, by violence, established itself on the basis of toleration of national usages, provided that its main institutions were accepted (worship of the Sun, active service in peace and war). Its civilizing influence spread along the royal roads; the process of assimilation went on by natural course. The Sierra was the centre of organization; the outlying parts were less acted upon.

CIVIL.

DOMESTIC.

MARITAL.

Traces of promiscuity; and also of capture.

Regulation by the Yncas: At a certain time marriageable young men (24) and women (18 to 20) assembled and were married, those of the royal family by the Ynca, the common people by the governors and Curacas. Consent of the parents required, and also of the parties (?).

The heir of the crown married his eldest (half ?) sister, and failing such sister the most nearly related cousin, niece, or aunt.

Those of royal blood married with their relations to the fourth degree, but with them, as with the common people, sisters were forbidden. No intermarriage between villages; in Cuzco even the two parts of the town were distinguished.

Previous cohabitation seems to have been the acknowledged rule.

Yncas and Curacas had many wives (one being the principal) and concubines. The most beautiful girls were kept in houses in all provinces for the use of the Ynca. The common people were not allowed to have more than one wife.

Women of noble rank were in liberal and independent positions; those of the common people were very much subjected to their husbands. Conjugal fidelity usual; chastity before marriage not regarded.

Apparently no divorce, the wife being considered as given by the Ynca.

Widows preserved chastity during one year. Marriage with a widow not very much approved.

FILIAL.

Sons dependent till 25.

Discipline watched over by the authorities.

Legitimate heir of the crown the first-born son of the principal wife; in event of failure, another legitimate son of the Ynca (chosen by the grandees) adopted by her, or the eldest relation of pure blood (traces of descent by females ?). Among the Curacas of the several provinces various independent customs of inheritance: the heir being the son of the principal wife, the next brother, or the sister's son (likewise traces of descent by females).

PUBLIC.

LAWS.

Criminal laws: The laws emanating from a sovereign of divine nature, justice was enforced even when the aggrieved person separated himself from the quarrel. For the same reason the common punishment was death. Capital crimes: burning bridges, &c., evasion of tolls, trespassing upon fields or dwellings by travellers, attempting to get access to the virgins of the Sun or the royal concubines (the whole family of the culprit put to death), or abetting it, adultery on their part, &c. Other punishments: flogging inflicted upon disorderly people, banishment, &c. Greatest crime, rebellion (the district laid waste and its inhabitants exterminated). Blasphemers stoned. The injured husband might kill his wife and the adulterer. Great severity against corrupt judges and officers. No private hunting allowed.

Agrarian law: Each Indian received a *tupu* of maizeland and another for each boy, a half for each girl. When a boy married, the father handed one *tupu* over to him.

The community gave a dwelling to the married couple.

"Brotherly law," compelling the inhabitants of each village to help each other.

No removal from one province to another allowed except by order of the Yncas. Strangers and travellers received as guests.

Laws against luxury; many articles—gold, silver, precious stones, *coca*, &c.—reserved for the use of the Yncas and those to whom they granted them.

Three or four festivals a month instituted by law, to which the poor were to be invited.

Dues on loads passing bridges (paid in kind).

GENERAL.

The government universally regulative, with patriarchal care.

Ranks: 1. King (*Ynca*), as child of the Sun, regarded with religious respect. Absolute lord and highest priest (sometimes officiating). If under a certain age, he was bound to act on the advice of the grandees.

2. The *Yncas*, tracing their pedigrees to a king (or some privileged follower of the first one ?). Many privileges.

3. *Curacas*, the former sovereigns of the conquered districts. Their relations.

4. Common people, divided in lineages.

5. Slaves (*Yanacuna*) ?

The inhabitants registered in groups of 10, 50, 100, 500, 1,000, superintended by officers from among them. Chiefs of 10,000. The decurions assisted their people, reporting their necessities to the superior officers, watched over the observation of laws, and reported the number of births and deaths. (Likewise registers kept at the gates of towns.) Governors for districts; delegated officers, representing the general government, and enforcing its requirements—collection of tribute, care of the royal road and its depôts, &c.

Lastly, the kingdom was divided into four districts (S., W., N., E.), under viceroys, presiding over councils of war, of justice, and of finance, and forming the king's council of state.

Orders passing downwards from rank to rank, reports in the same manner upwards.

All higher appointments conferred upon Yncas exclusively. In all important matters reference made to the king.

Visitations and travels of the king.

High judges in the chief towns of provinces (usually the governors). Disputes between provinces settled by the royal sent or a judge of the blood royal sent by him. Visitations of judges.

Land divided into three parts: of the *huacas*, of the Ynca, and of the people. The chase a royal privilege; the mines a royal monopoly.

The tributes consisted in personal labour, and the produce of it.

Unskilled labour: cultivating the lands of the Sun, and the Ynca, and those who could not work themselves (performed in common); repairing public works; personal service in palaces and temples; making shoes, clothes, &c., for the soldiers and those who could not work themselves.

Skilled labour: skilled workmen had to supply what the Yncas, *Curacas* and temples needed. Public works. Mines. Regular turn for villages and families (craftsmen worked two or three months). Yncas, Curacas, priests, officers, and soldiers during active service, men up to 25 and after 50 years of age, women, incapables, were exempt from tribute. The tribute, as far as not wanted for immediate use, was stored in depôts scattered over the country along the royal roads.

Public relief: From the flocks of llamas (appropriated almost exclusively to the Sun and to the Ynca), wool given to the Curacas and the common people to make clothes. In the Coast valleys cotton given from the royal estates. Meat distributed after the royal hunts. A part of the agricultural produce of the Ynca's estates stored in magazines for supplying the people in seasons of scarcity, and cases of destitution.

Mitimaes (colonists) sent from sterile provinces into more fertile ones, to support their relatives with products. The Ynca rule in conquered provinces maintained by garrisons and *mitimaes*.

LOCAL.

The *Curacas* retained their position, but were compelled to comply with the general rules of the Yncas, as represented by officers. Right of inheritance acknowledged. Sons residing a time at Cuzco.

Local tribes allowed to retain their former customs if not directly opposed to the worship and laws of the Yncas.

A judge in each village, appointed by the crown, obliged to settle the case within five days, or to refer it to a superior judge, according to its importance. No litigant could seek for justice beyond his own village. No appeal.

Monthly reports of the ordinary judges.

Accountants in every village.

Village superintendents of agricultural labour.

MILITARY.

General obligation to military service.

From the decurions' statistical reports the government fixed the quota to be contributed by each village as soldiers and porters.

Regular division of army, based upon decimal numeration.

Great order (different hair-dresses and uniforms). Body guard.

Heads of 10, 50, 100, 500, 1,000, 10,000 soldiers. The Curacas allowed to command their people, but commanders of the blood royal placed over them. Commander-in-chief generally the Ynca, or the heir-apparent. Subordinate officers appointed for life.

Military roads with depôts (of arms, cloth, provisions). Many large fortresses. Temporary field fortifications. Garrisons, mostly at the frontier places and in newly conquered districts. Royal banner. Banners of the squadrons. Martial music. Well ordered camps of cotton tents. Flocks accompanied the armies.

Military laws very severe. The soldiers not allowed to lodge in the villages, but in the depôts on the roads or in tents. Any trespass on the property of the inhabitants punished with death. No pillage in the subjugated provinces, when conquest intended and no special offence committed. Desertion punished with death. Women, married and unmarried, were allowed to accompany the armies.

The officers kept registers of the dead and wounded.

ECCLESIASTICAL.

Ecclesiastical government not separated from political.

The Ynca, as first-born son of the Sun, officiated at the great festivals of the Sun. Priests gave advice in war matters. The fortress of Cuzco a sacred place.

The high priest, appointing the subordinate priests, uncle or brother of the king, or at least a legitimate member of the royal family. All priests of the House of the Sun at Cuzco were Yncas; also the principal priest in each province (to maintain conformity with Cuzco), the others being relations of the Curacas.

The numerous priests officiated in the temples in weekly rotation. They offered the sacrifices, and announced divinations from omens, sacrifices, dreams, &c. They were not the keepers of knowledge. Human sacrifices.

Peculiar dress (?) Secret language (?).

Virgins of the Sun. *Ocllo*, women of royal blood, having taken a vow of chastity, without being secluded.

Estates and numerous temples of the Sun, with halls of the Moon, Stars, Thunder, &c. Central temple at Cuzco.

Huacas: things sacred, because of their unusual character (twins, monstrosities, &c.), or other relation with the deity (idols, offerings, tombs, abodes of gods, &c.).

Conopas: household gods. *Malquis:* mummies of the ancestors.

Fastings, confessions, pilgrimages, &c. With the Indians of Tarma the most religious persons were asked to fast for the benefit of others.

Three great festivals at Cuzco:—

1. *Yntip Raymi* (solemn feast of the Sun) in June, for thanksgiving. Rigorous fast before, no fire lighted, general sexual abstinence. Re-lighting of the sacred fire.

2. *Cusqui-raymi*, when the maize seed begun to sprout (to pray for its protection against frost).

3. *Situa*, in September, for expiation.

The superseded religions subsisting as popular beliefs under the Sun-worship (the official creed), there were other priests holding intercourse with the supposed gods and goddesses, mainly for soothsaying. The priest of the idol at Pachacamac had tributes due to him and some political power.

PROFESSIONAL.

Priestly office specialized.

Common people medically treated by old women. Herbalists of the Yncas and Curacas.

Amautas, wise men, and, as it were, official litterateurs.

Haravecs, bards.

Royal musicians.

Quipucamayus preserved the knots, and kept up the tradition of their meanings.

Accountants, &c.

CEREMONIAL.

MUTILATIONS.

Root of the nose bled for some sacrifices. (The Huancavillcas pulled out three teeth in each jaw of their children as a service very acceptable to their gods, originally as a sign of subjection.)

Ears bored for ear-rings (bored lips and nose-rings of the Huancavillcas).

Hairs on the chin pulled out.

Some tribes compressed the heads of the children, that they might become more healthy and do more work.

Family Marks(?).

Castration of the guards of concubines (?).

FUNERAL RITES.

Corpses scrupulously cared for.

The entrails of the Ynca kings and queens deposited in a temple at Tampu, the embalmed bodies placed in front of the figure of the Sun in the great temple at Cuzco. The bodies of other people marvellously preserved by natural action of the dry air of the Sierra or the hot sand of the Coast. All were wrapped in many coverings, the Ynca kings and queens in princely attire.

Different customs of burying in the several provinces. With the Collas the graves were round stone towers; near Quito, tumuli of earth and stone, the height probably signifying the dignity of the interred. With the Huancas the bodies were sewed in sheepskins, and preserved in the houses. Near Riobamba, &c., deep, square tombs were dug, in some cases within the houses. The Indians of Cuzco placed the dead chiefs in niches of the mountains; those of Loxa, &c., at secret places on the heights; those of Truxillo piled mounds of the figure of a loaf of sugar; those of Guayaquil constructed tombs with vaulted roofs; the Chinchas put the dead on cane beds, and covered them slightly with sand, &c., &c. The corpses had generally a sitting posture; the faces were generally turned in the Sierra towards east, on the Coast towards the sea.

With the Yncas and chiefs they buried their favourite servants and wives, provisions, treasures, &c. Others caused themselves to be buried at favourite places of the deceased.

Mourning rites performed by the people and by special (female) mourners: lamentations, sad music, songs, sacrifices, cutting off the hair of the women not killed, putting ashes on, and not taking care of own body, &c. These occur before the burial, and at it; and are repeated at certain intervals. Meals for the soul, which was supposed to return. The graves sacred (*huaca*). All palaces but one of a deceased king closed up; in this a sort of household was maintained. Servants kept for the dead. At certain festivals the bodies of the sovereigns brought out into the public square of the capital, and a banquet served. In the Coast valleys clothes and food in the tombs of the chiefs renewed from time to time; with the Huancas the bodies of the chiefs at certain seasons taken out by their sons and carried to the cultivated fields. In the Collao, &c., at the festivals of the mummies, the tombs sprinkled with the blood of sacrifices, and liquor poured over them.

LAWS OF INTERCOURSE.

Marks of distinction: The king alone privileged to wear the *llautu* (a red fringe across the forehead, hanging down to the eyes), a certain gold ornament, &c. No one allowed to wear the hair so short as he. The heir-apparent wore a small yellow fringe. A great emerald in the hair-dress was the distinguishing mark of the sovereigns of Quito; a circlet of wool, adorned with gold and silver, that of the ancient chiefs of Tumbez. The Yncas had the largest ear-holes (*Orejones*). To imitate the kings most closely in their badges was the greatest honour granted to vassals. The orders distinguished by the materials of dress and ornaments. Three kinds of cloth for common people, chiefs, and Yncas. Gold, silver, *coca*, &c., reserved to the use of the Yncas, and those to whom they granted it. Separate bridges, one for Yncas and Curacas, one for commonalty. A lance with a banner planted as a sign of the royal presence.

Titles: The descendants of the founder of the monarchy (and some of his followers ?) called *Yncas* (= sovereign lords) or *Yntip Churi* (= children of the Sun). The sovereign called *Sapa* (= only one), the queen *Coya*. Surname of the king: *huacchacuyac* (= friend of Poor); of the queen: *mamanchic* (= our mother).

The Ynca kings haughty to their subjects, and very grave. They rarely showed the face; it was not lawful to look at it. To touch the king without being an Ynca or specially allowed was sacrilege. The Ynca gave his replies by attendants.

Salutations of veneration: Bowing the head and the whole body, raising the eyes to heaven, stooping to the ground, raising the hands and opening them and kissing the air (paid only to Pachacamac, Sun, and king). A sacrifice of hairs of the eyebrows abridged to a gesture.

Signs of reverence: stripping off the sandals and bearing a load on the back. Kissing hands, feet, and face. Begging for work a courtesy due to ladies by inferior (female) visitors.

Signs of submission: having the hands tied and ropes round the necks, bearing green boughs and palm-leaves. They did not approach a superior without bringing a present.

Sign of contempt: spitting.

Sign of complacency: inviting to drink (also a salutation between equals).

HABITS AND CUSTOMS.

Many feasts. Three or four times a month all inhabitants of a village feasted together before their Curacas, and exercised themselves in military and public games.

Marriage festival public, as celebrated at the same time for a great many families.

The bridegroom served a few days for the bride. Ceremonies: both parties fasted two days, drank together some *chicha*; the bridegroom put a certain shoe on the foot of the bride.

Festival of the Ynca novices in knighthood (piercing of the ears). The youth promised to worship the Sun, to serve the king, and to sow maize.

Great festival of the Yncas at the weaning of the first-born son (shaving off the first crop of hair). Two name-givings. Sowing and harvest festivals.

Chief amusements: drinking and dancing.

They rose early, took the principal meal at 8 or 9 in the morning, supped before sunset, and went to bed early. They did not drink during the meal, but afterwards.

REGULATIVE.

SENTIMENTS.

ÆSTHETIC.

In the Sierra more cleanly than at the Coast. Women of Cuzco careful in combing out their hair.

Very fond of *coca* (for chewing) and tobacco (for snuffing).

Black considered the most perfect colour (black beasts for sacrifices, black dress of the kings). Grey (natural colour of the wool) colour of mourning. (In the province of Tarma, black.) Very fond of vermilion-red.

Much singing (during work, &c.).

Dancing popular.

Lyrical (amorous) poetry most in favour.

Decency in dress introduced by the Yncas.

Among some tribes gross indecency.

MORAL.

Moral state higher on the Sierra than at the Coast, in the North than in the South.

Cannibalism extirpated by the spreading Ynca government.

Unnatural offences, although severely prosecuted, continued here and there.

Were addicted to intoxicating liquors.

Chastity before marriage not cared for; even that of the virgins of the Sun doubted.

Prostitutes were tolerated.

In some provinces promiscuous sexual intercourse at festivals. The Indians of the Coast more lascivious than those of the Sierra, the nobles more than the common people.

The often-repeated accusation of falsehood is partly to be accounted for by the state of intimidation.

Great devotion to the Yncas.

Very kind-hearted (few quarrels) and grateful.

Although the usual Indian vices (except idleness) were observed as well with the Peruvians, their altruistic feeling, the gentleness and absence of covetousness, gave the conquerors a favourable impression.

IDEAS.

RELIGIOUS IDEAS AND SUPERSTITIONS.

Believe that the soul leaves the body during sleep, and the things dreamed of are what it sees in the world in the meantime. Therefore great attention paid to dreams and their interpretation.

Soul considered immortal. Common belief in a general resurrection as a continuation of present life. Therefore great care taken to preserve nail-pairings, hairs, &c., and to put them together, that they might be found easily. (Atahuallpa's horror lest he might be burnt thus gets its explanation.)

The *Amautas* asserted there were three worlds: upper, lower, and lowest earth. In their opinion the good went to the first, and were rewarded by a life of rest of mind and body in the house of the Sun; the wicked went to the last, and were punished by a life of suffering in the house of Supay the Lord of the Dead. The future life believed to be physical. The common belief recognized only one world to come. *Upa mavca*, *i.e.*, dumb land, beyond a great river; the place where the huacas are; the Coast islands, &c., were supposed to be the regions of the other world. Here and there belief in the transmigration of souls. (The Canches believed that the souls of the deceased went to a great lake, where they thought that they came from, and entered into the bodies of the new-born.)

Fetichism and ancestor-worship. Any striking thing might be taken up and considered *conopa* (household god); inherited, it became god of the family. Unusually fertile stalks of maize, &c., were considered invested with power over the other stalks, and therefore worshipped (*saramamas*). In the emerald country of Manta an emerald was highest god. Thus all things might become *huaca*.

Strong chiefs were worshipped. The *malquis* (mummies) of the ancestors, and figures representing them, became the main objects of worship. Likewise *pacarinas* (places of origin) adored.

Sun worship was introduced by the Yncas into all conquered provinces, while the local cults were fully tolerated. As the Sun appears not only as a celestial body but as a man (father of the first Ynca), fetichism and ancestor-worship are united. Besides the sun, the moon, some stars, the thunder, the earth, the sea were worshipped. Ynca Yupanqui (1439–75) proclaimed an universal creator, probably grafting the new idea on half-extinct notions of elder gods (Viracocha).

Some moral ideas connected with religion (as is shown by the belief in a punishment of the wicked).

Strong belief in soothsaying, signs, &c. Meteors regarded as signs of a great misfortune approaching. Some tribes believed that their ancestors came out of fountains, rocks, lakes. Myths of giants and dwarfs.

Four was sacred number.

Chicha thrown into the channels and rivers to have rain. At sowing festivals great noise of arms was made to prevent diseases of the plants. They would not expose their teeth to the rainbow for fear they should decay. The superstition of "eating souls" existed. Belief that one of two twins is child of the ray, &c.

KNOWLEDGE.

Knowledge withheld from the common people.

They used decimal notation, and were able to express numbers to any extent required.

Years marked by the solstices (beginning at that of the summer—December 22nd), and divided into twelve months, marked by the new moon, with intercalary days to adjust the whole. The months divided into two halves by the increasing and waning of the moon, and into weeks. No naming of days.

(The Collas had a year of ten months.)

Observation of solstices, equinoxes, and eclipses, but no knowledge of their causes. Eclipses regarded as a sign of wrath for some offence, on the part of the Sun, or of illness, on the part of the Moon. Also observation of Venus, the Pleiades, and some other stars.

The earth supposed to be above the water, which is entered by the sun at night.

Rainbow recognized as derived from the sun (device of the Yncas).

Land measured by cords.

Some knowledge of chemistry and mechanics shown in the arts.

Abundance of medicinal plants made use of. They made powder of plants, mixed also several in water. Washings. Ointments. Plasters. Warm baths. Purges and bleedings. They recognized illness by looking at the tongue and the heightened colour.

Skill shown in preparing poisons.

Geography: maps with lines raised on them to mark boundaries and localities.

History: records of events made up in brief statements by the *Amautas*, and preserved with aid of knots by the *Quipucamayus*.

LANGUAGE.

A great many dialects (those of the Sierra kindred, but different from those of the Coast); during the Yncas' supremacy more or less superseded by the Quichua as the enforced language of the governing race.

Special dialect of the Court (also Quichua ?).

Secret language of the priests (?)

Alphabet: A, B, D, F, G, J, V, W, X, Z wanting. Some peculiar guttural sounds.

Language exceedingly sweet by predominance of vowels. Accent generally on the penultimate syllable.

Constructive character: agglutinative (polysynthetic).

Difference of gender expressed by distinct words: as to relationship, even the sex of the speaker. Plurality denoted in different ways. To express a great quantity the word repeated. No termination required when a numeral added. Inclusive and exclusive plurals of the first person. When the action passes from one person to another, the expression forms one word, and is conjugated. Four classes of such transitions.

Syntax very simple. The concordance of adjective and substantive must be understood. The deed always precedes the doer. Adjective always before the substantive.

Descriptive names.

No writing (early hieroglyphs ?).

The *quipu*, properly a means of numeration, employed as a mnemonic symbol.

ANCIENT PERUVIANS.

ORGANIC ENVIRONMENT.

t Region: Vegetation only on the banks of the streams. Luxuriant sea vapours are densest (end of June). Most of tropical plants .

ra: In the northern low valleys all the intertropical plants and the higher parts maize, fruit-trees, herbs in abundance. In the tatoes, &c.

ana: Immense vegetation of all kinds.

puma, jaguar, bear, deer, llama, alpaca, guanaco, vicuña, wild boar, or, tortoise, condor, myriads of sea-birds, &c.

SOCIOLOGICAL ENVIRONMENT.

Principal aboriginal nations: The *Yuncas* of the Coast are widely different from the inhabitants of the four Andes regions of Quitu, Chinchasuyu, the Centre (*Quichuas — Yncas?— Canas, Chancas, Huancas, Rucanas*), the Collas. Apparently no intercourse with foreign civilised races.

PHYSICAL CHARACTERS.

Quichuas: Short stature; square shouldered and broad chested; small hands and feet, and comparatively large head. Hair black. Little beard. Aquiline nose, thick lips, small chin; rather high cheek-bones, horizontal eyes with arched brows. Forehead high, but somewhat receding.

Collas: Shorter stature, coarser features.

EMOTIONAL CHARACTERS.

Not impulsive. Patient, obedient, industrious. Friendly to one another, and kind to animals. Good-humoured and gentle.

INTELLECTUAL CHARACTERS.

Unspeculative, uninventive, strongly imitative. Inhabitants of the Sierra more intelligent than those of the Coast.

owed by the Yuncas, who in some valleys (Chimu, &c.) arrived at considerable civilization. Some traces of a previous civilization. In the Sierra there are no traces of an older civilization. After an intermediate period of barbarism, a new civilization was founded by the gradual conquest of the whole range of Sierra and Coast, from Quito to Chili, by the Yncas, according to the native tradition from about A.D. 1000. Spanish Conquest from 151.

L.

FUNCTIONAL.

IVE.

REGULATIVE.

OPERATIVE.

ASTICAL.

CEREMONIAL.

PROFESSIONAL.	MUTILATIONS.	FUNERAL RITES.	LAWS OF INTERCOURSE.	HABITS AND CUSTOMS.
go-eparat-l. s first-e Sun, great Sun. vice in The zco a st, sub-uncle f the ast a ber of All House Cuzco o the n each ntain thers f the riests nples tion. acri-d di-mens, &c. the edge. (?) (?). Sun. royal ken a with-d. amer-the f the nder, emple s an-their ities, ation idols, .). ehold num-zors. es-, &c. ns of eligi-sked nefit ivals wi f the igor-o fire exual ight-fire. si, seed (to ction re-as nder (the here ests rse sed ses, ay-the nse to cal	Priestly office specialised. Common people medically treated by old women. Herbalists of the Yncas and Curacas. *Amautas*, wise men, and, as it were, official litterateurs. *Haravecs*, bards. Royal musicians. *Quipucamayus* preserved the knots, and kept up the tradition of their meanings. Accountants, &c.	Root of the nose bled for some sacrifices. (The Huancavillcas pulled out three teeth in each jaw of their children as a service very acceptable to their gods, originally as a sign of subjection.) 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These occur before the burial, and at it; and are repeated at certain intervals. Meals for the soul, which was supposed to return. The graves sacred (*huaca*). All palaces but one of a deceased king closed up; in this a sort of household was maintained. Servants kept for the dead. At certain festivals the bodies of the sovereigns brought out into the public square of the capital, and a banquet served. In the Coast valleys clothes and food in the tombs of the chiefs renewed from time to time; with the Huancas the bodies of the chiefs at certain seasons taken out by their sons and carried to the cultivated fields. In the Collao, &c., at the festivals of the mummies, the tombs sprinkled with the blood of sacrifices, and liquor poured over them.	*Marks of distinction:* The king alone privileged to wear the *llautu* (a red fringe across the forehead, hanging down to the eyes), a certain gold ornament, &c. No one allowed to wear the hair so short as he. The heir-apparent wore a small yellow fringe. A great emerald in the hair-dress was the distinguishing mark of the sovereigns of Quito; a circlet of wool, adorned with gold and silver, that of the ancient chiefs of Tumbez. The Yncas had the largest ear-holes (*Orejones*). To imitate the kings most closely in their badges was the greatest honour granted to vassals. The orders distinguished by the materials of dress and ornaments. Three kinds of cloth for common people, chiefs, and Yncas. Gold, silver, *coca*, &c., reserved to the use of the Yncas, and those to whom they granted it. Separate bridges, one for Yncas and Curacas, one for commonalty. A lance with a banner planted as a sign of the royal presence. *Titles:* The descendants of the founder of the monarchy (and some of his followers?) called *Yncas* (= sovereign lords) or *Yntip Churi* (= children of the Sun). The sovereign called *Sapa* (= only one), the queen *Ccoya*. Surname of the king: *huacchacuyac* (= friend of Poor); of the queen: *mamanchic* (= our mother). The Ynca kings haughty to their subjects, and very grave. They rarely showed the face; it was not lawful to look at it. To touch the king without being an Ynca or specially allowed was sacrilege. The Ynca gave his replies by attendants. *Salutations of veneration:* Bowing the head and the whole body, raising the eyes to heaven, stooping to the ground, raising the hands and opening them and kissing the air (paid only to Pachacamac, Sun, and king). A sacrifice of hairs of the eyebrows abridged to a gesture. *Signs of reverence:* stripping off the sandals and bearing a load on the back. Kissing hands, feet, and face. Begging for work a courtesy due to ladies by inferior (female) visitors. *Signs of submission:* having the hands tied and ropes round the necks, bearing green boughs and palm-leaves. They did not approach a superior without bringing a present. *Sign of contempt:* spitting. *Sign of complacency:* inviting to drink (also a salutation between equals).	Many feasts. Three or four times a month all inhabitants of a village feasted together before their Curacas, and exercised themselves in military and public games. Marriage festival public, as celebrated at the same time for a great many families. The bridegroom served a few days for the bride. Ceremonies: both parties fasted two days, drank together some *chicha*; the bridegroom put a certain shoe on the foot of the bride. Festival of the Ynca novices in knighthood (piercing of the ears). The youth promised to worship the Sun, to serve the king, and to sow maize. Great festival of the Yncas at the weaning of the first-born son (shaving off the first crop of hair). Two name-givings. Sowing and harvest festivals. Chief amusements: drinking and dancing. They rose early, took the principal meal at 8 or 9 in the morning, supped before sunset, and went to bed early. They did not drink during the meal, but afterwards.

SENTIMENTS.

ÆSTHETIC.	MORAL.
In the Sierra more cleanly than at the Coast. Women of Cuzco careful in combing out their hair. Very fond of *coca* (for chewing) and tobacco (for snuffing). Black considered the most perfect colour (black beasts for sacrifices, black dress of the kings). Grey (natural colour of the wool) colour of mourning. (In the province of Tarma, black.) Very fond of vermilion-red. Much singing (during work, &c.). Dancing popular. Lyrical (amorous) poetry most in favour. Decency in dress introduced by the Yncas. Among some tribes gross indecency.	Moral state higher on the Sierra than at the Coast, in the North than in the South. Cannibalism extirpated by the spreading Ynca government. Unnatural offences, although severely prosecuted, continued here and there. Were addicted to intoxicating liquors. Chastity before marriage not cared for; even that of the virgins of the Sun doubted. Prostitutes were tolerated. In some provinces promiscuous sexual intercourse at festivals. The Indians of the Coast more lascivious than those of the Sierra, the nobles more than the common people. The often-repeated accusation of falsehood is partly to be accounted for by the state of intimidation. Great devotion to the Yncas. Very kind-hearted (few quarrels) and grateful. Although the usual Indian vices (except idleness) were observed as well with the Peruvians, their altruistic feeling, the gentleness and absence of covetousness, gave the conquerors a favourable impression.

IDEAS.

RELIGIOUS IDEAS AND SUPERSTITIONS.	KNOWLEDGE.
Believe that the soul leaves the body during sleep, and the things dreamed of are what it sees in the world in the meantime. Therefore great attention paid to dreams and their interpretation. Soul considered immortal. Common belief in a general resurrection as a continuation of present life. Therefore great care taken to preserve nail-pairings, hairs, &c., and to put them together, that they might be found easily. (Atahuallpa's horror lest he might be burnt thus gets its explanation.) The *Amautas* asserted there were three worlds: upper, lower, and lowest earth. In their opinion the good went to the first, and were rewarded by a life of rest of mind and body in the house of the Sun; the wicked went to the last, and were punished by a life of suffering in the house of Supay the Lord of the Dead. The future life believed to be physical. The common belief recognized only one world to come. *Upa marca, i.e.*, dumb land, beyond a great river; the place where the huacas are; the Coast islands, &c., were supposed to be the regions of the other world. Here and there belief in the transmigration of souls. (The Canches believed that the souls of the deceased went to a great lake, where they thought that they came from, and entered into the bodies of the new-born.) Fetichism and ancestor-worship. Any striking thing might be taken up and considered *conopa* (household god); inherited, it became god of the family. Unusually fertile stalks of maize, &c., were considered invested with power over the other stalks, and therefore worshipped (*saramamas*). In the emerald country of Manta an emerald was highest god. Thus all things might become *huacas*. Strong chiefs were worshipped. The *malquis* (mummies) of the ancestors, and figures representing them, became the main objects of worship. Likewise *pacarinas* (places of origin) adored. Sun worship was introduced by the Yncas into all conquered provinces, while the local cults were fully tolerated. As the Sun appears not only as a celestial body but as a man (father of the first Ynca), fetichism and ancestor-worship are united. Besides the sun, the moon, some stars, the thunder, the earth, the sea were worshipped. Ynca Yupanqui (1439–75) proclaimed an universal creator, probably grafting the new idea on half-extinct notions of elder gods (Viracocha). Some moral ideas connected with religion (as is shown by the belief in a punishment of the wicked). Strong belief in soothsaying, signs, &c. Meteors regarded as signs of a great misfortune approaching. Some tribes believed that their ancestors came out of fountains, rocks, lakes. Myths of giants and dwarfs. Four was sacred number. *Chicha* thrown into the channels and rivers to have rain. At sowing festivals great noise of arms was made to prevent diseases of the plants. They would not expose their teeth to the rainbow for fear they should decay. The superstition of "eating souls" existed. Belief that one of two twins is child of the ray, &c.	Knowledge withheld from the common people. They used decimal notation, and were able to express numbers to any extent required. Years marked by the solstices (beginning at that of the summer—December 22nd), and divided into twelve months, marked by the new moon, with intercalary days to adjust the whole. The months divided into two halves by the increasing and waning of the moon, and into weeks. No naming of days. (The Collas had a year of ten months.) Observation of solstices, equinoxes, and eclipses, but no knowledge of their causes. Eclipses regarded as a sign of wrath for some offence, on the part of the Sun, or of illness, on the part of the Moon. Also observation of Venus, the Pleiades, and some other stars. The earth supposed to be above the water, which is entered by the sun at night. Rainbow recognized as derived from the sun (device of the Yncas). Land measured by cords. Some knowledge of chemistry and mechanics shown in the arts. Abundance of medicinal plants made use of. They made powder of plants, mixed also several in water. Washings. Ointments. Plasters. Warm baths. Purges and bleedings. They recognized illness by looking at the tongue and the heightened colour. Skill shown in preparing poisons. *Geography:* maps with lines raised on them to mark boundaries and localities. *History:* records of events made up in brief statements by the *Amautas*, and preserved with aid of knots by the *Quipucamayus*.

LANGUAGE.

A great many dialects (those of the Sierra kindred, but different from those of the Coast); during the Yncas' ascendancy more or less superseded by the Quichua as the enforced language of the governing race. Special dialect of the Court (older Quichua?). Secret language of the priests (?). Alphabet: B, D, F, G, J, V, W, X, Z wanting. Some peculiar guttural sounds. Language exceedingly sweet by predominance of vowels. Accent generally on the penultimate syllable. Constructive character: agglutinative (polysynthetic). Difference of gender expressed by distinct words: as to relationship, even the sex of the speaker. Plurality denoted in different ways. To express a great quantity the word repeated. No termination required when a numeral added. Inclusive and exclusive plurals of the first person. When the action passes from one person to another, the expression forms one word, and is conjugated. Four classes of such transitions. Syntax very simple. The concordance of adjective and substantive must be understood. The deed always precedes the doer. Adjective always before the substantive. Descriptive names. No writing (early hieroglyphs?). The *quipu*, properly a means of numeration, employed as a mnemonic symbol.

PROCESSES.

DISTRIBUTION.	EXCHANGE.	PRODUCTION.	ARTS.	REARING, ETC.
Distribution partly by government. Distribution of the raw materials for clothing, and, in case of scarcity, of food-supplies out of the depôts of the government. Mitimaes sent from sterile to fertile countries to despatch certain products home. Bamboo canes for *balsas* (boats) sent by government to all the rivers. Droves of llamas used as beasts of burden. Noblemen carried in litters. Couriers (with regular system of relays) for carriage of goods and transmission of intelligence. They took five days between Cuzco and Quito. At certain seasons markets between Coast and Sierra. Some trading at the frontiers.	Exact weights and measures. No money. Gold and silver used only for ornaments, &c. Barter restricted to a few commodities.	Human labour almost the only power used. Llamas used as beasts of burden. Smelting stoves brought to the top of hills to make use of the wind.	Fire produced by friction (and by a concave mirror?). Cookery very simple (hearths of clay with one to three holes above). Ground the corn on broad tiles by another tile. Made vinegar, sugar, treacle, and numerous fermented beverages, especially of maize. Dried meat, potatoes, herbs, fruits. Spinning (with spindles of cane). Great proficiency in weaving and dyeing. Wove not on the loom, but with simple distaffs. Dyed by unfading vegetal and mineral colours. Embroidering. No tanning; but skin rubbed with grease until it is flexible. Pottery very highly developed with Quichuas as well as with Yuncas. Washed gold. Silver, copper, tin and (to a small extent) quicksilver dug. Silver fluxed by addition of a base metal (nearly all lead) in small portable ovens fused by the wind of mountains. Second and third melting in the houses, blowing by pipes of copper. Metals cast, soldered, hammered into various forms. Stamping. Metal-workers used certain hard stones for anvils. Marvellous masonry. Quarrymen used black pebbles for rubbing the stones. Working of emeralds. Carpentry. No nails; the woods fastened together with reed. Hammers, axes, adzes and billhooks made of copper (with tin) and of stone. Skilful fishing and hunting.	*Domestic animals:* two kinds of llamas (divided into flocks according to colour). Further, a kind of duck, Guinea pigs, dogs. Some pets. (No indigenous animal afterwards added to this number). The wild *huanacus* and *vicuñas* treated like tame animals by a certain selection at the great hunts. *Cultivated plants:* Maize, wherever cultivable. In colder regions *quinoas* and potatoes. *Oca* and *añus* (two varieties of *Oxalis*). Numerous vegetables. A kind of pepper. Coca (in the forests). In the Coast valleys: maize, *yucas (Tatropha Manihot Lin.)*, sweet potatoes *(Batatas edulis)*, cotton, &c. Fruit trees. Cinnamon. Highly developed agriculture promoted by government: extension of arable land; introduction of llama-rearing into newly-conquered provinces; encouragement of husbandry. Arable land extended by constructing channels, building *andenes* (terraces) in the Sierra, and digging *hojas* (diggings below the arid soil) on the Coast. Most careful tillage notwithstanding bad tools. No plough, but sharp-pointed stake, with a horizontal piece to put the foot on. Working in concert. The land manured in the Sierra by pulverized human manure and dung of llamas; on the Coast by heads of sardines; in both parts by guano. Pastures. The flocks brought to graze at certain times. Sheepfolds.

PRODUCTS.

LAND-WORKS	HABITATIONS, ETC.	FOOD.	CLOTHING.	IMPLEMENTS.	WEAPONS.	ÆSTHETIC PRODUCTS.
Gigantic ancient mounds. Fortifications: palisades, deep holes with bristling stakes, covered with straw. Fortresses (with walls "*en tenaille*"). Causeways. Royal roads over the Sierra and at the Coast, partly cut out of the living rock, partly paved, with walls or guide-posts. Bridges of stone, wood, net-work. Wonderful irrigating channels over the most rugged tracts of the Sierra and in the Coast valleys. Dykes. Terraces as substructures for buildings, and to obtain arable land on the sides of mountains. Diggings not very deep for silver, gold, lead, emeralds, &c. Wells on the Coast (very ancient).	Materials large *adobes* (clay mixed with straw and dried in the sun) especially in the Coast-valleys, masonry, very exactly placed and plastered over, in the Sierra. Wooden houses in the north. Huts of cane on the Coast. Very solid roofs of straw (in the Sierra), or matting (at the Coast), placed upon beams. No mortar of lime and sand, but a mixture of red clay. No upper story. Small square windows and deep recesses of the same size in the walls of palaces, to contain gold figures, &c. The sides of the openings straight-lined and sloping. No arched vaults, but vaults of the straw roofs, like bells, in some cases several uniting. Doorways hung with mattings. Palaces scattered over all the provinces along the royal roads, with splendid interior. Open courts with fountains in the centre. Large halls attached. Orchards. Baths. Gorgeous temples. The Indians originally had their villages in the mountain fastnesses. Under the Ynca government they descended into the valleys, &c. Villages mostly scattered (those in the Collao closer together). Round the stations of the royal roads cities grew up. Streets narrow. Squares.	Light food mostly used. Maize principal food, toasted or boiled in pure water. Bread with most of the tribes rarely used, because of the difficulty of grinding corn. In default potatoes, ocas, quinua, batatas, &c. All sorts of sweet and bitter herbs (the latter boiled twice or thrice, dried in the sun, and kept through the winter). No dish without *uchy*, the pepper of the Indians (*capsicum*). In the north cinnamon the common seasoning. Meat scarce with the common people, except after the great hunts; dried meat preserved (*charqui*). On festivals, one of the bred Guinea pigs killed. The inhabitants of the Coast ate flesh and fish raw. Honey of wild bees very much valued. No use of the milk of llamas (llamas producing little). Numerous beverages. Thick and a little brackish water and maize; it failing, quinua grains, berries of the *molli*-tree, &c. Rain-water collected in the leaves of the *maguey* (*Agave Americana*), mixed with maize, quinua or *molli*-seeds.	Decent dress introduced by the Yncas. The Indians of Cuzco better dressed than those of the other provinces. Short shirts and long mantles of wool (Sierra) or cotton (Coast). No sleeves or collars; openings for head and arms. Different materials for the several orders. Women of Cuzco: long mantle extending from the neck to the feet, having holes for the arms, and being fastened round the waist by a broad belt; over this another mantle falling from the shoulders to the feet. Robes of batskins (worn by the Ynca). Variegated liveries. Sandals of aloe-fibres. Soles of llama skin, fastened with cords of reed or wool. Head covering: only with the Collas, and Canas, a cap (but bands, &c., general as distinguishing tribe marks).	No iron. Instruments of copper hardened with tin, or stone. Knives of copper and stone. A lancet (pointed stone fixed into a cleft stick) for bleeding. Combs of thorns. Pins of metal, for fastening women's cloaks. Cords and cables of aloe-fibres. Baskets of rushes. Perfectly balanced scales. Looking-glasses of polished silver, stone, and bronze. Tiles for grinding corn. Bells of silver and bronze. Hearths of clay. Canes for blowing the fire (tubes, air-holes in the furnaces). Numerous sorts of drinking vessels of gold, silver, and clay (with handles in the middle, and mouth at one end). Low stools. Bed clothes (no mattresses). Tapestry. Napkins. Sacks. Bags. Litters. The furniture of the Ynca palaces was of gold and silver. *Balsas* (rafts of bamboo, &c.), with deck, sail, and moveable keel. Substitutes: calabashes, put in a net, and rolled up bundles of rushes; a board (like a saddle) served the swimming boatman to place his head on. Thick canes were used as oars. Fishing implements: harpoons, bad fish-hooks, small nets.	Offensive: very long lances, darts, battle-axes, clubs, slings (the stones being carried in small bags), bows and arrows (not poisoned). Sticks with large knobs of metal (with five or six sharp points). *Ayllus*, consisting of three round stones sewn up in leather, and each fastened to a cord a cubit long. Thrown at the horses, they bound the legs together. Heated stones wrapped in cotton used as fire-balls. Defensive: small shields of boards, jackets of quilted cotton, breast-plates, head-pieces of wood, with many folds of cotton reaching to the eyes.	*Personal adornments:* Blackened the hair. The young women of the blood royal put vermilion in a line from the corner of the eyes to the temples. (Tattooing in Quito and on the northern coast.) Different hair-dresses of the several provinces. Ear-rings (nose-rings of the Huanca-villcas; chiefs near Guayaquil fastened bits of gold on the teeth). Bracelets. Collars. Crowns of small gold beads worn by the Indians of Guayaquil, &c. *Object adornments:* Walls carved into human figures, &c., or, if plastered, painted or lined with plates of gold and silver. Emeralds let into the stone. Bricks and roofs painted. Pottery made in every natural form. Drinking vessels in grotesque forms and humorous designs. Combination of animate and inanimate forms. The designs of the pottery of the Coast (shells, fish, &c.) differed from those of the Sierra. Weapons adorned with feathers. Embroidering. Patterns woven in stuffs. Cloth decorated with feathers. Figures stamped on thin gold plates. Gold vases decorated with jewels. Historical paintings. Stone and gold figures of animals and men. Flowers, fruits, leaves of beaten gold. Stone figures at doorways (like guards). Architecture symmetrical. Several periods distinguished. *Dancing:* Peculiar way in each province; always connected with singing. The dances permanent. Dances of both sexes. Stately dance of the Yncas. *Music:* Each song had its appropriate tune. Drums sounded with one stick, and trumpets. Instruments made of hollow reeds; four or five reeds tied in a row, each one having the point higher than its neighbour. Harsh singing. *Literature:* Songs in measured verses without rhyme, to record traditions (secular and religious); love ditties, mourning songs, &c. Plays performed.